NATURE

No. 4379 SATURDAY, OCTOBER 3, 1953 Vol. 172

CONTENTS

	Page
Professional and Academic Responsibility and Freedom	597
Three Hundred Years of American Psychology. By Prof. John Cohen	599
Scientific Work on Barley. By Sir John Russell, O.B.E., F.R.S.	600
Theory and Applications of Fluid Dynamics	600
Radio Techniques for Radar. By Dr. R. A. Smith	602
Mass Spectrometry. By Dr. James Bell	602
'Actively Acquired Tolerance' of Foreign Cells. By Dr. R. E. Billingham, L. Brent and Prof. P. B. Medawar, F.R.S.	603
Transmutation of the Elements. By Dr. R. Spence, C.B.	606
Importance of Titanium and its Alloys in Engineering	608
Kumasi College of Technology, Gold Coast. By Dr. J. P. Andrews	609
Obituary:	
Dr. Colin Campbell. By Prof. E. R. H. Jones, F.R.S., and Dr. G. Norman Burkhardt	610
News and Views	611
Analysers and Computers for Electrical Systems	614
Microwave Optics. By Dr. E. Wolf	615
Census of Woodland Areas less than Five Acres in Great Britain. By Prof. H. G. Champion, C.I.E.	616
Characteristics of the Ionosphere in Great Britain	617
The Expressions 'Golgi Apparatus', 'Golgi Body' and 'Golgi Substance'. By Dr. John R. Baker	617
Porphyrin *A* and Other Porphyrins from Heart Muscle. By Dr. R. Lemberg, F.R.S.	619
Mechanism of Phage Action. By Margeris A. Jesaitis and Walther F. Goebel	622
Letters to the Editors:	
Growth of Excised Fern Leaves in Sterile Culture.—Dr. I. M. Sussex and Dr. Taylor A. Steeves	624
Action of Irradiated Cytoplasm on Untreated Chromosomes of the Silkworm.—Prof. Yoshio Nakao	625
Dark-Ground Illumination of Ram Spermatozoa.—H. M. Dott	626
Carotene: a Rachitogenic Factor in Green-feeds.—A. B. Grant	627
Tryptophane Metabolism in Rice Moth Larva (*Corcyra cephalonica* St.).—T. K. Sundaram and P. S. Sarma	627
Are *Torulae* Haploid?—Dr. M. K. Subramaniam and B. Ranganathan	628
Prochromosomes and Supernumerary Chromosomes in *Rhinanthus minor* Ehrh.—David J. Hambler	629
Origin of Reverse Thermo-remanent Magnetism of Igneous Rocks.—Prof. T. Nagata, S. Akimoto and S. Uyeda	630
Radiocarbon Dating: Large-scale Preparation of Acetylene from Organic Material.—Dr. H. Barker	631
Use of an Acetylene-filled Counter for Natural Radiocarbon.—Dr. A. R. Crathorn	632
Daily Variation of Amount of Ozone in the Atmosphere.—Dr. K. R. Ramanathan and Bh. V. Ramana Murthy	633
Eddies in Turbulent Jet Diffusion Flames.—Prof. M. W. Thring	634
Antibody Chromatography on an Immunologically Specific Adsorbent.—L. S. Lerman	635
Nosean as a Tracer Mineral.—Dr. A. G. Lowndes	636
Milk Yield of Hill Ewes.—J. B. Owen	636
Influence of Inorganic Sulphate on the Copper-Molybdenum Interrelationship in Sheep.—A. T. Dick	637
Absence of the Sickle Cell Trait in Seventy-two Australian Aboriginals.—W. R. Horsfall and Dr. H. Lehmann	638

Editorial and Publishing Offices of "NATURE"
MACMILLAN & CO., LTD.,
ST. MARTIN'S STREET, LONDON, W.C.2.
Telephone Number: Whitehall 8831. Telegrams: Phusis Lesquare London

Annual subscription £6, payable in advance, postage paid to any part of the world

Advertisements only should be addressed to
T. G. Scott & Son, Ltd., Crown House, 143–147 Regent Street, London, W.1
Telephone Number: Regent 3891

All rights reserved. Registered as a newspaper at the General Post Office

PROFESSIONAL AND ACADEMIC RESPONSIBILITY AND FREEDOM

A PASSAGE in the address which Sir John Maud delivered last October to the Federation of British Industries Conference on the universities and industry, in which he discussed the use made by the Civil Service of the university graduate and the qualities of the graduate that have proved most valuable, deserves consideration in a wider context. First and second among the valuable qualities—though not in any way implying that the university graduate had any monopoly of them—Sir John put integrity and courage. The administrative officer in the Civil Service, he said, particularly needs the characteristic type of integrity which the graduate should possess—a passionate respect for the truth, a respect which would set limits even to what a Minister could say. Sir John suggested that, from his experience of Civil servants, a Minister who wanted to answer a Parliamentary question in a way that was not true would have to draft the answer himself, and this referred also to all papers which Ministers send to the Cabinet when they wish to propound their own policy. There is a limit, he said, even to what can be said in Parliamentary debates, and it is set by the refusal of a self-respecting administrative officer to put forward a brief which is not justified by the facts.

That refusal, of course, demands courage as well as integrity, and while Sir John went on to illustrate his point further in regard to gaining acceptance for new ideas, there are reasons for specially welcoming this reference to the importance of integrity and courage, not only in the public service but also in public life. The sudden dismissal of Dr. Allen V. Astin from his post as director of the U.S. National Bureau of Standards in circumstances which suggest that an attempt was being made to influence a technical judgment or report by political or other considerations has deeply perturbed many American scientists and technologists; he has, of course, recently been reinstated. Scientists as well as others in Great Britain are not happy at the way in which Prof. W. A. Lewis has left the board of the Colonial Development Corporation. If these misgivings are, in fact, quite unfounded, the persistent refusal of the Secretary of State for the Colonies to give any explanation as to why the appointment was not renewed is all the more mysterious. Mr. Oliver Lyttelton can scarcely be unaware that existence of a belief, whether well founded or not, that the appointment was terminated because Prof. Lewis gave unpalatable advice to the Colonial Office, is unlikely to encourage the recruitment to the Colonial service of scientific and technical experts of the standard of professional ability, integrity and impartiality that is most desirable.

Nor would it be difficult to multiply examples where plain and independent speaking by the expert on public issues is important. Quite irrespective of the political issues of nationalization and its merits or demerits, the technician and transport engineer have a right to protest against the disregard of

technical considerations, such as the adverse effect on technical efficiency if decentralization of railway regions is carried too far. The smooth and efficient operation of great public services cannot be secured if two great political parties insist on profoundly disturbing their work and keeping policy and organization in uncertainty by making them the plaything of party politics. Those who are concerned with the technical operation of transport or the iron and steel industry have a clear right to point out the difficulty of operating effectively, and at the same time to insist that the national interest demands imperatively that the future of such industries shall be determined on the basis of reasonable accommodation and not left to the prejudice or intransigence of political parties. Again, while Prof. S. Zuckerman's committee is considering the possibility of contamination of food through the use of insecticidal sprays in crop protection, as regards the wider question of additions to foodstuffs and the chemical manipulation of foods, the Government's attitude, as revealed in the House of Lords debate on June 10, reveals a disturbing reluctance to consider the whole question in its relation to health and disease.

It is against this background of the need both for integrity and courage as well as sound technical or professional judgment in public life, in the public service and in industry, and for independent centres of impartial, responsible criticism of public policy—the independent centres of reflexion of which Sir Hector Hetherington spoke in his Essex Hall Lecture—the judgment and integrity of which command confidence and respect, that the questions of academic freedom and the rights and responsibilities of universities are most appropriately considered to-day. This point of view, however, was not reflected in the discussions on "Science and Freedom" at the European Congress for Cultural Freedom held at Hamburg last July (*Nature*, **172**, 445; 1953), although there was some serious discussion of influences which could hamper the free development of science in the modern world, and the University Grants Committee was several times commended as a model agent for the discrete distribution of government subsidies, without usurping the scientist's or scholar's right of self-direction. The Chancellor of the Exchequer took a similar view of academic freedom when he addressed the recent Congress of Universities of the Commonwealth at Cambridge.

Mr. Butler expressed the view that, while there is little danger of direct Government interference or of parsimony, there is a danger that the development of the universities might be moulded gradually, not so much by the independent desires of the universities themselves, as by the call for the production of particular types of specialists. Academic autonomy is impaired in fact, if not in name, by the granting or withholding of funds for particular purposes by external authority, such as the Government. This is, of course, the root of the objection to the ear-marked grant, as has been explained very fully by the University Grants Committee. It also lies at the root of the objections of the American universities to Federal assistance, as Dr. H. W. Dodds, president of Princeton University, explained to the same Congress, and was earlier emphasized by him and L. M. Hacker and Prof. Lindsay Rogers in the memorandum they submitted to the Commission on Financing Higher Education.

Such misgivings point to one reason why such a device as the University Grants Committee is unsuitable for American conditions; but as already stated, this is too narrow an approach to-day to the consideration of this question of academic freedom. Nor is the issue appropriately discussed solely from the angle which is suggested by current discussion on political influence. In his Castner Memorial Lecture to the Society of Chemical Industry last April on the role of technology in American chemical industry, Mr. R. C. Swain, while admitting that a very few men and women have used this cloak of academic freedom to cover subversive activities, was emphatic that this confers on governments no right of interference in academic matters; it is a problem that should be the responsibility of trained academic administrators and not of politicians.

Mr. Swain fully endorsed the conclusion reached by the Association of American Universities in a statement* on the rights and responsibilities of universities and their faculties, adopted on March 24, 1953: "We assert that freedom of thought and speech is vital to the maintenance of the American system and is essential to the general welfare. Condemnation of Communism is not to be interpreted as readiness to curb social, political or economic investigation and research. To insist upon conformity to current beliefs and practices would do infinite harm to the principle of freedom, which is the greatest, the central American doctrine".

The interest of this statement for British universities, however, lies only partly in its formulation of academic freedom as essential to social and national welfare. It lies even more in the derivation of its argument for, and defence of, academic freedom from a consideration of the nature of a university and its role in national life. Only, in fact, when the function of a university in the society and world of to-day is clearly understood can the significance of academic freedom be rightly appreciated and sound proposals formulated to safeguard it either from abuse or infringement.

In this statement, the Association of American Universities points out that the modern university is a unique type of organization; like its medieval prototype, it is an association of individual scholars, united in loyalty to the ideal of learning, to the moral code, and to the country and its form of government, representing diversified fields of knowledge and expressing many points of view. Freedom of enterprise, moreover, is as essential to intellectual as to economic progress, and a university must therefore be hospitable to an infinite variety of skills and viewpoints, relying upon open competition among them as the surest safeguard of truth, just as Milton argued. The whole spirit of a university requires investigation,

* The Rights and Responsibilities of Universities and their Faculties: a Statement by the Association of American Universities, adopted Tuesday, March 24, 1953. Pp. 16. (Princeton, N.J.: Dept. of Public Relations, Princeton University, 1953.)

criticism, and presentation of ideas in an atmosphere of freedom and mutual confidence. To enjoin uniformity of outlook upon a university faculty would put a stop to learning at the source.

This, the statement points out, is the real meaning of academic freedom, and it rightly adds that it is essential not only that the governing board should guarantee a faculty this freedom, but also that the reasons for such a guarantee should be understood by the public. From quite a different approach we thus find the same insistence on public understanding as has been emphasized in recent discussions as a condition for the continued effective functioning of the University Grants Committee in Great Britain. Moreover, the importance of public understanding is further emphasized when we consider the position of the university in relation to disputed questions of scholarship or matters of public policy, where both technical or scientific as well as political issues may be involved.

In all such matters, the Association of American Universities points out, a university does not take an official position of its own lest it in any way discourage or hinder the pursuit of truth or the advancement of knowledge. To fulfil his function, the university student or scholar must continue to analyse, test, criticize, and re-assess existing institutions and beliefs, approving when the balance of evidence supports them and disapproving when the weight of evidence is on the other side. Nor can such investigations be limited to the physical world. The fact that moral, social and political progress has not kept pace with mastery of the physical sciences points to the need in these spheres for more inquiry, criticism and inventiveness, including the study, if necessary, of unpopular ideas. Further, the statement recognizes frankly that the scholar may be compelled to challenge popular disapproval or prejudice. In the field of his own competence, the scholar may have a duty to speak and to proclaim truth even when it is unpalatable.

The freedom, and with it the responsibility, to proclaim the truth is one of the most important functions of the university in the modern world.

THREE HUNDRED YEARS OF AMERICAN PSYCHOLOGY

History of American Psychology

By A. A. Roback. Pp. xiv+426+28 plates. (New York: Library Publishers, Inc.; London: George Allen and Unwin, Ltd., 1952.) 42*s*. net.

DR. ROBACK has given us a learned and lively account of American psychology since 1640. His aim is to do justice to the pre-experimental period, which had previously been studied in detail only by W. J. Fay, and to deal more fully with certain problems than is possible in general historical works.

He divides the period under review into three stages: 1640–1890, 1890–1910, and 1910–50. The first phase begins with Harvard's earliest curriculum, the achievement of Henry Dunster, a clergyman educated in England. English, Scottish and German scholarship seems to have dominated the American academic world in Colonial days, and its leading figures displayed a keen interest in problems of a psychological character. Many such topics (for example, "The fancy produces real consequences") formed the subjects of theses submitted by Harvard candidates for a bachelor's degree in physics. Psychology was then a sub-division of physics known as pneumatics (or pneumatology).

Dr. Roback's treatment of the second phase covers more familiar ground. Its novelty lies in its vivid character studies. These are often based on personal acquaintance and on hitherto unpublished correspondence. German influence was predominant, especially the voluminous writings of Wilhelm Wundt (that "formidable philosophical cobbler", as Gasset calls him), though McKeen Cattell absorbed Galton's statistical ideas into the United States; and Titchener believed that his studies at Leipzig had not altered the English character of his thinking.

In the second half of the book Dr. Roback devotes himself to the third phase and becomes much more controversial in his emphasis and assessments. His comparative lack of enthusiasm for Hull's behaviour theory may be deduced from the scanty space allotted to it. Nor is he decided whether Prof. E. C. Tolman's elaborate system, embodying as it does elements of all the schools, is more than a 'colourful crazy quilt'. He reserves some very sharp words both for factor analysis and for operationism, while neo-scholastic psychology escapes lightly. Finally, after presenting the luminaries of psychology, he adds an annotated inventory of the lesser lights, the personified footnotes to history.

One of Dr. Roback's difficulties is the fact that many of America's most distinguished psychologists have been refugees from Nazi Germany whose fame was established before they left Europe. It remains to be seen whether the work of men like Wertheimer, Lewin and Köhler will leave a lasting mark on American psychology or whether they will suffer the fate of William MacDougall. We learn from Dr. Roback that the Americans looked upon MacDougall not only as an outsider, but also as a foreigner who wished to impose his views on them. It would be a mistake to overlook the profound differences between American and European points of view. According to Prof. Allport of Harvard, the Americans have "motorized" psychology, and he adds that "only behaviourism in both its muscle-twitch and operational versions is primarily American". This gives us a clue to the divergence.

A few decades ago, Dr. Roback tells us, Europeans believed that no psychology was to be expected in the land of the dollar. Nowadays there may be a belief that no psychology is to be expected in countries short of dollars. Prof. Boring, for example, has spoken of "the psychologist's handicap of living in England". We may be forgiven for wondering, therefore, what sort of history of American psychology would be written by a European. In 1930 Pierre Janet remarked to Dr. Roback, "Les Américaines—ils ont des édifices magnifiques, des laboratoires impressives—mais de psychologie . . ."; and K. R. Lorenz recently stated (in "Physiological Mechanisms in Animal Behaviour"), "an American journal masquerades under the title of 'comparative psychology' though to the best of my knowledge no really comparative paper has ever been published in it".

Evidently some Europeans do not share the Americans' estimate of their own work.

The American Psychological Association now has ten thousand members as compared with a handful at the turn of the century. We must wait to see whether the achievements of this army are commensurate with its increase in size. John Cohen

SCIENTIFIC WORK ON BARLEY

The Barley Crop

By Dr. Herbert Hunter. (Agricultural and Horticultural Series.) Pp. ix+187+12 plates. (London: Crosby Lockwood and Son, Ltd., 1952.) 21*s*. net.

BARLEY is one of the most interesting of all farm crops. It has a wider tolerance of climatic conditions, and therefore a wider geographical distribution than any other cereal, and its grain has a greater range of uses depending on its composition and the form in which its constituents exist. It has long been fortunate in its students and historians. Six years ago E. S. Beavan's remarkable volume "Barley, Fifty Years of Observation and Experiment" was published posthumously, and now Dr. Hunter has prepared this connected account of his well-known and highly valued experiments with this crop. These were begun in Ireland, where he was for long responsible for the barley investigations conducted by the Department of Agriculture in association with Messrs. Arthur Guinness and Co., an account of which he published in 1926 in a book also called "The Barley Crop". Since then much new material has accumulated. The National Institute of Agricultural Botany at Cambridge has been continuously studying barley varieties since 1919, and the Institute of Brewing ran a long series of chemical and field studies from 1920 onwards. The Danish investigators also have been very active and have produced some remarkably good varieties. Dr. Hunter has rendered a valuable service in putting together this material and making an interesting book of it.

The book opens with a detailed account of the botanical classification of the genus *Hordeum* and a brief history of barley in Britain from prehistoric times to the present day. The records go back to the Neolithic period: barley grains somehow got into the clay in the making of pots; they were burnt during the firing but left an impress in the clay from which it is possible to effect some measure of identification. Even in those days—five thousand years ago—both naked and hulled types occurred, the former predominating more and more as time went on; but in the Iron Age, and still more in the Anglo-Saxon period, the hulled barley was the more common. Some actual grains have been found which show that the type was six-rowed *H. hexastichum* as shown on Greek and early Roman coins: two-rowed barley was not found in Britain until just before the Christian era. However it got here, it is now our chief type; the six-rowed sorts are mainly winter or spring varieties not very widely grown.

When agricultural surveys were first made in Britain a number of different varieties were recorded in different parts of the country; some of them still survive and have proved of great value to plant breeders. Dr. Hunter has been strikingly successful with Spratt, crossing it with Archer to produce Spratt–Archer, one of the most popular malting varieties, and with Archer Goldthorpe to produce Camton, a short stiff-strawed variety that will stand up to high manuring, and, while not popular with maltsters, is of great feeding value.

The Danish breeder, H. A. B. Vestergaard, has produced at Abed in Lolland some outstanding varieties, early ripening and resistant to lodging; some of them, notably Kenia and Maja, have proved very useful in Britain. As the combined result of suitable varieties, high manuring for the preceding sugar beet, and sound management, the Danish farmers obtain the highest yield of barley in the world—51·8 bushels per acre; Great Britain comes next with 39·2 bushels.

The effect of manuring, weather conditions, cultural conditions and other factors on yield and quality of the grain are discussed with special reference to the Irish experiments; it would have been interesting to have compared these with the long series of experiments made under the Institute of Brewing scheme, particularly to see if the relations with rainfall were paralleled in Ireland.

In conclusion, the author discusses the objects at which the plant breeder should aim, rightly emphasizing the need for resistance to lodging. Most experts will agree with Dr. Hunter that high yield and high quality can be combined, but very high yields may be less compatible with high quality.

The book can be strongly recommended to all who are interested in barley: it gives in clear concise form an admirable summary of present knowledge of this most interesting crop. E. John Russell

THEORY AND APPLICATIONS OF FLUID DYNAMICS

High-Speed Aerodynamics

By Prof. Harold W. Sibert. (Prentice-Hall Aeronautical Engineering Series.) Pp. xiii+283. (New York: Prentice-Hall, Inc., 1948.) n.p.

Supersonic Aerodynamics

A Theoretical Introduction. By Edward R. C. Miles. Pp. xi+255. (London: McGraw-Hill Publishing Co., Ltd., 1950.) 34*s*.

Aerodynamics of High Speed

Facsimiles of Nineteen Fundamental Studies as they were Originally Reported in the Scientific Journals. With a Bibliography compiled by Prof. George F. Carrier. Pp. xi+286. (New York: Dover Publications, Inc., 1951.) Paper, 1.75 dollars; cloth, 3.50 dollars.

High-Speed Aerodynamics

By W. F. Hilton. Pp. ix+598. (London, New York and Toronto: Longmans, Green and Co., Ltd., 1952.) 60*s*. net.

Essentials of Fluid Dynamics

With Applications to Hydraulics, Aeronautics, Meteorology and other Subjects. By Prof. Ludwig Prandtl. Authorized translation. Pp. x+452. (London and Glasgow: Blackie and Son, Ltd., 1952.) 35*s*. net.

PROF. H. W. SIBERT'S book is intended for undergraduate students of aeronautical engineering. The mathematical development is strictly elementary in character and is set out in full detail. Almost all the examples are numerical in character, and, although such computations are by no means

to be despised, it is a melancholy commentary on the standards achieved in American colleges that it has not been possible to include any problems giving developments of the theory. The book is an admirably clear account of the foundations of high-speed aerodynamics. However, the derivation of the formula for the speed of sound as given in Chapter 5 is perhaps an exception to this general statement, as it seems to imply that there is no distinction between the speed of the fluid and the speed of sound through the fluid.

The range of the book can be estimated from the fact that it gives a derivation of the Busemann parabolic formula, and not the von Kármán formula for wave drag on a projectile. The formulæ for the lift and drag on rectangular wings of finite aspect ratio are given without proof.

The book contains a large number of practical applications to such matters as altimeters, air-speed indicators, problems of control and stability at high Mach numbers, and the determination of wind drag on a wake survey.

Dr. Miles's text-book is strictly of an introductory character, and is intended primarily for university students of aeronautical engineering whose mathematical equipment goes very little beyond the usual course in the calculus. The book therefore contains very full mathematical details of such matters as the theory of characteristics, and even fuller details of the construction of the potential equation in cylindrical and spherical co-ordinates. Curiously enough, Busemann's name does not appear in the index, although the Busemann coefficients are obtained in the last chapter. The theory of shock waves is given in considerable detail, together with a full account of the Taylor–Maccoll investigation of the supersonic flow over a right circular cone. The book contains a number of examples, a great many of which are numerical in character. The von Kármán theory of wave drag on slender pointed bodies of revolution is not given. Full particulars of the numerical theories problem are included. There is a detailed account of the graphical-computational method of characteristics for axially symmetric supersonic flow.

Mathematicians and physicists in English-speaking countries already owe a heavy debt of gratitude to Dover Publications of New York for making available so many classical treatises in different branches of mathematics and mathematical physics. Prof. Carrier's book contains a number of especially attractive features. It is addressed to students of theoretical aerodynamics, and consists of photographic facsimiles of nineteen original studies, including the famous papers by Rankine and Taylor on shock waves, of Glauert on the effect of compressibility on lift, the pioneer investigations of Prandtl, Busemann and von Kármán, together with papers by Possio, Lighthill, Tomotika and Tamada, and many others. It is therefore an invaluable resource book for students in this subject.

There can be no doubt that the initiative of the Dover Publications in producing a super students' edition will be greatly appreciated. The present volume is also enriched with a very useful bibliography.

Hilton's book is a lively and exciting account of high-speed aerodynamics written especially for the aeronautical engineer. The author is certainly to be congratulated on the success with which his literary style conveys to the reader the sense of interest and importance and urgency of the problems which he discusses. The book covers almost the entire field of high-speed aeronautics. It begins with a general survey of the basic observational and experimental effects about subsonic, transonic and supersonic flow. This section very rightly opens at once with a discussion of shock stall and its effects upon drag. Then follow the consideration of compressibility, effects on lift and pressure, a study of the effect of shock stall on pitching moment, and a valuable chapter on stability and control. This, however, could have been improved if the definition of the coefficient a_1, a_2, b_1, b_2 were given at the very beginning instead of being indicated in casual asides.

The next section gives a good summary of the theory of supersonic flow over wings of infinite aspect ratio, of finite aspect ratio, and over pointed bodies of revolution. The theory of conical flow is referred to very briefly, so briefly indeed that it is unlikely that the terse summary on pp. 312–313, for example, would convey very much to the practical designer. In this connexion, it is a pity that Evvard's elegant theory of tip effects has not been included.

The third section gives a very interesting account of the high-speed wind tunnels, and of the special apparatus and techniques which are needed for high-speed measurements.

The fourth and concluding section of the book contains the formal mathematical theory of shock waves, together with some valuable sections on propellers and jet propulsion.

The author writes throughout as a practical tunnel man who has gained his experience at the National Physical Laboratory, Teddington, and the Applied Physics Laboratory, Washington. His eyes are always firmly fixed upon the practical problems and upon the limitations of the approximate theories which have been devised to correlate experimental observations. There are numerous original features in the book, such as the use of "carpet diagrams" for the representation of the variation of lift coefficients with incidence and Mach number. The author does not hesitate to express his personal opinions in very decisive language, and there are places in which some of the details of his presentation may be questioned as not entirely accurate; but the broad general picture is certainly painted with energy and enthusiasm, and there is no doubt that this book will form a most valuable addition to the library of every student of high-speed aeronautics.

"The Essentials of Fluid Dynamics", by Prandtl, is a magnificent account of the physical basis of fluid dynamics by one who did so much to create the subject by his own researches. The emphasis in this work is essentially upon the experimental data, and upon the engineering applications, but the mathematical theory, although maintained on a strictly elementary level, is sufficiently developed to correlate physics and engineering. The present work will naturally suggest a comparison with the book by Tietjens on "Fundamentals of Hydro and Aero Dynamics", which was based on Prandtl's lectures, and translated into English by Prof. Rosenhead in 1934. The present book by Prandtl himself covers far more ground, and as regards mathematical theory is, in the reviewer's opinion, considerably simpler than the earlier work. Prandtl covers a vast field, including hydrostatics, hydraulics, aeronautics, meteorology, theory of turbulence, and lubrication. The aerodynamical applications are, of course, of the greatest importance, and they include a good elementary account of the theory of aerofoils, pro-

pellers and windmills, together with a good introduction to supersonic flow. The section on hydraulics includes an introduction to the theory of open water courses, and shock waves on running water, together with a sketch of the theory of water turbines and pumps. The extensive section on meteorology gives an account of the basic theory of winds and of the general circulation of the air over the surface of the earth. Numerous other topics are covered in this book, including, for example, the theory of heat transfer and lubrication; but perhaps enough has been said to indicate its immense range.

Throughout this great survey, the hand of the master is evident in the powerful use of quite elementary theory to correlate complex phenomena in applied dynamics. On one hand, the book is admirably suited to a student who is approaching the subject for the first time and who wishes to start from its physical basis; on the other, it is, in fact, almost a small encyclopædia which can be used with great profit as a book of reference by the most advanced research students.

RADIO TECHNIQUES FOR RADAR

Radio and Radar Technique

By Dr. A. T. Starr. Pp. xviii+812. (London: Sir Isaac Pitman and Sons, Ltd., 1953.) 75*s*. net.

THE great advances in radio and electronic techniques which have taken place in the past two decades were largely stimulated by the war-time work on radar. Most of this work has already been published in a vast number of papers in the technical and scientific journals. The American and some British work has been collected together in the very comprehensive series of books prepared by the Radiation Laboratory, Massachusetts Institute of Technology, and published by McGraw-Hill. A good deal of the British work has also appeared in the much more compact but still fairly comprehensive series published by the Cambridge University Press. The aim of the present book is to compress most of this work into a single volume. The author has of necessity had to exercise discrimination in choice of material, leaving aside much that is only of limited interest or has become obsolete. That he has succeeded in covering the field in a single volume, even though somewhat bulky, is no small achievement, and there will be many who will prefer to have the material for easy reference in this form. Most of the subject-matter has already appeared in print; but the author frequently adds valuable hints for the engineer based on his own wide experience of these techniques. The compression necessary in such a volume will, however, lead most serious workers in the field to read the more specialized books on the different aspects of the subject which have already been published.

The main broad advances which have been made lie in the use of circuit techniques to generate the wide variety of wave-forms which enable modern electronic equipment to carry out such complex functions, and in the extension of the usable radio spectrum to the microwaves. Since much of the equipment was designed to work at the limits set by random fluctuations of a fundamental nature, a much better appreciation of the properties and character of electrical 'noise' was obtained. These matters are dealt with, and, in particular, the development of valves for the generation of microwaves is discussed. Chapters are also included on aerials and waveguides, and on the principles of modulation and communication of information generally.

Some mathematical treatment is given in the text; but the bulk of the theory is relegated to a long series of appendixes which occupy about one-quarter of the book. A bibliography is given at the end of each chapter; but this seems to have been chosen rather arbitrarily, and is by no means a complete account of the original papers nor a suitable guide for a beginner to the literature on the subject. Frequently reference is made to war-time reports of Government establishments. These reports are not generally available, and in any event contain material which has been published elsewhere. The book is well produced though the scale of many of the figures is too small for numerical use. For a book containing such a wealth of information the price is not excessive.

R. A. Smith

MASS SPECTROMETRY

Mass Spectrometry

Report of a Conference organized by the Mass Spectrometry Panel of the Institute of Petroleum and held in Manchester, April 20–21, 1950. Pp. vi+205. (London: Institute of Petroleum, 1952.) 30*s*.

MASS spectrometry has rapidly become a technique of major importance in both routine testing and research investigations, and it was with the object of assisting in the application of this technique that the Mass Spectrometry Panel of the Institute of Petroleum was formed. The present volume reports the proceedings of a conference, organized by the panel, held in Manchester in 1950, and is a valuable addition to the literature on this subject.

Fourteen papers by established workers, surveying almost the whole field of mass spectrometry, are conveniently divided into four distinct groups, the first group dealing, appropriately, with the fundamental problem of the ionization and dissociation of molecules, and comprising four papers covering topics such as the measurement of appearance potentials and the consideration of the information derived from these, the determination of bond dissociation energies, and the detection of free radicals. The second group is concerned with instrumental aspects of mass spectrometry and contains a description of a French mass spectrometer followed by a paper discussing aspects of ion source design—one of the most important features of the modern mass spectrometer.

Applications of the mass spectrometer and the preparation of standard gases for calibration purposes are dealt with in the third and fourth groups; these are of more general interest and may, therefore, be the sections of greatest appeal to the reader not closely connected with this type of work, since the subjects discussed include isotope enrichment, isotope abundance measurements, syntheses using carbon-13, and some uses of stable isotopes. Also included in this section is a valuable discussion of the problems involved in the preparation of standard hydrocarbon samples.

A most acceptable feature is the provision of a very complete and classified bibliography on mass spectrometry from 1938 to the end of 1950; this in no small measure makes amends for the delay in the publication of the report.

James Bell

'ACTIVELY ACQUIRED TOLERANCE' OF FOREIGN CELLS

By Dr. R. E. BILLINGHAM*, L. BRENT and Prof. P. B. MEDAWAR, F.R.S.

Department of Zoology, University College, University of London

THE experiments to be described in this article provide a solution—at present only a 'laboratory' solution—of the problem of how to make tissue homografts immunologically acceptable to hosts which would normally react against them. The principle underlying the experiments may be expressed in the following terms: that mammals and birds never develop, or develop to only a limited degree, the power to react immunologically against foreign homologous tissue cells to which they have been exposed sufficiently early in fœtal life. If, for example, a fœtal mouse of one inbred strain (say, *CBA*) is inoculated *in utero* with a suspension of living cells from an adult mouse of another strain (say, *A*), then, when it grows up, the *CBA* mouse will be found to be partly or completely tolerant of skin grafts transplanted from any mouse belonging to the strain of the original donor.

This phenomenon is the exact inverse of 'actively acquired immunity', and we therefore propose to describe it as 'actively acquired tolerance'. The distinction between the two phenomena may be made evident in the following way. If a normal adult *CBA* mouse is inoculated with living cells or grafted with skin from an *A*-line donor, the grafted tissue is destroyed within twelve days (see below). The effect of this first presentation of foreign tissue in adult life is to confer 'immunity', that is, to increase the host's resistance to grafts which may be transplanted on some later occasion from the same donor or from some other member of the donor's strain. But if the first presentation of foreign cells takes place in fœtal life, it has just the opposite effect: resistance to a graft transplanted on some later occasion, so far from being heightened, is abolished or at least reduced. Over some period of its early life, therefore, the pattern of the host's response to foreign tissue cells is turned completely upside down. In mice, it will be seen, this inversion takes place in the neighbourhood of birth, for there is a certain 'null' period thereabouts when the inoculation of foreign tissue confers neither tolerance nor heightened resistance—when, in fact, a 'test graft' transplanted in adult life to ascertain the host's degree of immunity is found to survive for the same length of time as if the host had received no treatment at all.

Earlier Work

The literature of experimental embryology is rich in evidence that embryos are fully tolerant of grafts of foreign tissues. It is less well known (though no less firmly established) that embryonic cells transplanted into embryos of different genetic constitutions may survive into adult life, although their hosts would almost certainly have rejected them if transplantation had been delayed until after birth. The transplantation of embryonic melanoblasts[1] provides the most conspicuous evidence of this phenomenon—not because melanoblasts are peculiar in their immunological properties, but simply because their genetic origins are at once betrayed by the pigmentation of the cells into which they ultimately develop. Unfortunately, experiments with embryonic melanoblasts, having been done with quite different purposes in mind, do not make it possible to decide whether survival into adult life is due to an antigenic adaptation of embryonic cells which have been obliged to complete their development in genetically foreign soil, or whether it is due to a suppression or 'paralysis'[2] of the host's immunological response.

An exactly comparable phenomenon has been described by Owen[3], who found that the majority of dizygotic cattle twins are born with, and long retain, red blood cells of dizygotic origin: each calf contains a proportion of red cells belonging genetically to itself, mixed with red cells belonging to the zygote lineage of its twin. There is no reason to doubt that this is because the cattle twins, being synchorial, exchange blood in fœtal life through the anastomoses of their placental vessels. (This is not a peculiarity of cattle, for a human twin with red cells of dizygotic origin has lately been described[4].) Inasmuch as the provenance of the red cells was revealed by their reactions with specific agglutinins, it is most unlikely that the survival of foreign erythrocyte-forming cells into adult life was made possible by any kind of antigenic adaptation. Moreover, we have found that the majority of cattle twins at birth and for long after are fully tolerant of grafts of each other's skin[5]. Being freshly transplanted, these grafts can have had no opportunity to 'adapt' themselves antigenically to foreign hosts, but they survived nevertheless.

The experiments of Cannon and Longmire[6] have a direct bearing on the phenomenon of actively acquired tolerance. About 5–10 per cent of skin grafts exchanged between pairs of newly hatched chicks of different breeds are tolerated and survive into adult life; but the percentage of successes falls rapidly as the age at which the chicks are operated increases, and reaches zero by the end of the second week. These results will be referred to later.

Experiments with Mice

A single experiment will be described in moderate detail: the recipients were mice of *CBA* strain, the donors of *A* strain. The data for transplantations between normal mice of these strains are as follows. The median survival time of *A*-line skin grafts transplanted to normal *CBA* adults (regardless of differences of sex, or of age within the interval 6 weeks–6 months) is $11{\cdot}0 \pm 0{\cdot}3$ days[7]. In reacting against such a graft, the host enters a state of heightened resistance; a second graft transplanted up to sixty days after the transplantation of the first survives for less than six days, and immunity is still strong, though it has weakened perceptibly, after four months. Heightened resistance may be passively transferred to a normal *CBA* adult by the intraperitoneal implantation of pieces of lymph node excised from a *CBA* adult which has been actively immunized against *A*-line skin[8].

In the experiment to be described (Exp. 73), a *CBA* female in the 15–16th day of pregnancy by a

* British Empire Cancer Campaign Research Fellow.

CBA male was anæsthetized with 'Nembutal', and its body wall exposed by a median ventral incision of the skin. The skin was mobilized but not reflected, and particular care was taken not to damage the mammary vessels. By manipulation of the abdomen with damped gauzes, six fœtuses were brought into view through the body wall. Each was injected intra-embryonically with 0·01 ml. of a suspension of adult tissue cells through a very fine hypodermic needle passing successively through the body wall, uterine wall, and fœtal membranes. (The inoculum itself, consisting of a suspension in Ringer's solution of small organized tissue clumps, isolated cells, and cell debris, had been prepared by the prolonged chopping with scissors of testis, kidney and splenic tissue from an adult male *A*-line mouse.) After injection of the fœtuses, the skin was closed with interrupted sutures.

Five healthy and normal-looking young were born four days later; of the sixth fœtus there was no trace. Eight weeks after their birth, when the lightest weighed 21 gm., each member of the litter was 'challenged' with a skin graft from an adult *A*-line donor. The first inspection of the grafts was carried out eleven days later, that is, at the median survival age of *A*-line skin grafts transplanted to normal *CBA* hosts. The grafts on two of the five mice were in an advanced stage of breakdown; the grafts on the other three (one male and two females) resembled autografts in every respect except their donor-specific albinism. Each of these three grafts became perfectly incorporated into its host's skin and grew a white hair pelt of normal density and stoutness. Fifty days later, one of the three mice received a second *A*-line graft from a new donor, and this graft also settled down without the least symptom of an immunological reaction.

The graft on one of the three animals underwent a long-drawn-out 'spontaneous' involution, beginning somewhat before the 75th day after transplantation and ending with complete breakdown shortly after the 91st day. The other two mice were made the subjects of an experiment[9] designed to show that acquired tolerance is due to a failure of the host's immunological response and not to an antigenic adaptation of the grafted cells. When the two grafts were of 77 and 101 days standing, respectively, and still in immaculate condition, their hosts were inoculated intraperitoneally with chopped fragments of lymph nodes from normal *CBA* mice which had been actively immunized against *A*-line skin. The grafts began to deteriorate 2–3 days later, with signs of vascular congestion and stasis; contracture, hardening and discoloration took place progressively, and the grafts were reduced to dry scabs by the fourteenth day after the nodes had been implanted. It follows that tolerant hosts are fully capable of giving effect to a state of immunity which has been elicited by proxy, and that the tolerated grafts have not lost their ability to respond to it.

The fertility of the mice was entirely unimpaired. Both females repeatedly bore litters of normal size by their male litter mate. When they had grown up, two litters (of six and eight respectively) were challenged with grafts of *A*-line skin. Breakdown of all the grafts was far advanced or complete by the eleventh day after their transplantation.

The results of Exp. 73 demonstrate the great (but not necessarily indefinite) prolongation of the life of homografts made possible by a pre-emptive exposure of their hosts to foreign homologous cells. Beyond this, they demonstrate (*a*) that this prolongation of life is not due to an antigenic transformation of the grafts, nor to a competitive absorption of antibodies by, for example, cells of the fœtal inoculum which had survived into adult life; and (*b*) that acquired tolerance is either not transferred to, or is too weak or too ephemeral to make itself evident in, the offspring.

Two of the five mice of Exp. 73 gave no evidence of increased tolerance of *A*-line cells. We suppose that this was because they were imperfectly injected. Only in one experiment so far has every injected fœtus given rise to a tolerant adult.

The more important results obtained from the investigation of other litters may be summarized as follows. (1) The conferment of tolerance is not of an all-or-nothing character; every degree is represented, down to that which gives the test-grafts only a few days of grace beyond the median survival time of their controls. (2) The conferment of tolerance is immunologically specific. Thus a *CBA* mouse made tolerant of *A*-line tissue, or vice versa, retains the ability to react with unmodified vigour against skin from a donor belonging to a third strain, *AU*. (Equally clear evidence of the specificity of acquired tolerance is given in the following section.) But it has so far been our experience that the transplantation of (say) *AU* skin to a *CBA* mouse that is tolerant of *A*-line cells will elicit a reaction which, in addition to destroying the *AU* graft, causes an *A*-line graft already in residence to go through a severe immunological crisis. Although we have evidence of a sharing of tissue antigens between strains *A* and *AU*, this phenomenon is difficult to interpret, for the antigens common to strains *A* and *AU* are merely a sub-group of those to which the *CBA* host is manifestly unresponsive. It may therefore turn out that the continued well-being of a tissue homograft upon a tolerant host depends upon the quiescence of the antibody-forming system, and that if this is awakened by tissue antigens other than those of which the host is tolerant, antibodies directed against its, until then, tolerated graft may be formed as well. (3) A wide histological variety of tissue cells is capable of conferring tolerance to homografts of skin. It is by no means obligatory that skin cells, or even epithelial cells, should be among them. (4) We have inoculated ninety-six new-born mice with adult or fœtal tissue cell suspensions to decide whether tolerance can be conferred by exposure to foreign cells at this relatively advanced stage of development. The majority received a single inoculation of cells as soon as possible after birth; a small subgroup of these was injected with 0·05 mgm. cortisone acetate on the same occasion and several more times during the first week of life in an attempt to delay the maturation of the antibody-forming system[8]. The remainder of the new-born mice received repeated injections of foreign tissue cells in increasing quantities over the period of a month from birth. In all, only nine mice (about 10 per cent: cf. the experiments of Cannon and Longmire referred to above) showed an increase of tolerance when tested with a skin graft from the donor strain, and six of these were members of a single litter of eight which had received a single inoculation of cells, without cortisone, immediately after birth. It is of particular interest that when challenged with skin grafts in adult life the great majority of inoculated new-born mice showed neither tolerance nor enhanced resistance. New-born mice are, in general, too old for a tissue inoculum to confer

tolerance, and too young for it to confer immunity; the epoch of birth represents a null period during which the net outcome of exposure to foreign cells is to leave its subjects in a state of unaltered reactivity. (5) Grafts removed from hosts which have tolerated them, and then transplanted to normal mice of the host's strain, survive 2–3 days longer than freshly transplanted homografts of normal skin. Such homografts cannot, however, be compared directly with homografts of normal skin, because a high proportion of the corium of each will probably have been replaced by cells and cellular derivatives of host origin.

Preliminary Experiments with Chickens

Donors and recipients in these experiments were of Rhode Island Red and White Leghorn breeds, respectively. Skin transplanted from two weeks old Rhode Island Red chicks to White Leghorn recipients of the same age, using Cannon and Longmire's methods[8], is completely destroyed within ten days of grafting, to the accompaniment of an inflammatory reaction of conspicuous violence.

The embryonic chick is particularly well suited to experiments which make use of cellular inoculation, because the intravenous route is so easily accessible. Using methods demonstrated to us by Dr. C. Kaplan, whose help has been of the greatest value, we have obtained successful results by transfusing 0·2 ml. unmodified whole blood from an 11–12 day old embryonic Rhode Island Red donor into a chorio-allantoic vein of a White Leghorn embryo of the same age. Fourteen days after hatching, a test-graft of skin was transplanted to the recipient from its original donor. In seven such trials, five grafts showed prolongation of survival; of these, three succumbed within fifty days to the accompaniment of very much subdued inflammatory changes, and two still survive, with normal growth of red feathers, to the present time (125 days).

The success of these experiments has been found to depend on the strict pairing of donors with recipients. The transplantation of skin between our Rhode Island Red chicks when two weeks old showed them to be a highly heterogeneous assembly, in spite of their uniformity of breed characters. It is therefore understandable that chicks made tolerant to grafts from one Rhode Island Red donor will not, in general, accept grafts from another. This strict specificity of acquired tolerance has made it difficult to test the efficacy of grafts transplanted to the chorio-allantois, for an embryonic donor must be killed to provide tissues suitable for grafting. This difficulty has been circumvented by killing a young hatched donor, storing its skin[10] for later use in the test operation, and grafting fragments of a wide variety of its tissues upon the chorio-allantoic membrane of 10–11 day old White Leghorn recipients. Tolerance is conferred less regularly and less completely by this method than by blood transfusion: only three out of seven such experiments have yielded test grafts which survived for longer than twice their normal expectation of life, and those which have done so have given evidence of chronic low-grade inflammatory changes.

Washed blood corpuscles are as effective as whole blood in conferring tolerance; plasma is therefore a dispensable ingredient. If adult blood proves to be capable of conferring tolerance, it should be easy to decide whether red cells or white cells or both are efficacious.

Discussion

It is one of the predictions of Burnet and Fenner's[11] theory of immunity that the exposure of animals to antigens before the development of the faculty of immunological response should lead to tolerance rather than to heightened resistance. The homograft immunity system is particularly well suited to the appraisal of such a hypothesis, because the antigens are at once powerful, innocuous and persistent. For this reason, no great weight should be attached to failure of the experiments of Burnet, Stone and Edney[12] to verify it. It must be emphasized, however, that our experiments do not yet bear upon the fundamental problem of whether the production of antibodies represents an *inherited* derangement of protein synthesis, that is, a transformation which can persist through repeated cell divisions after the disappearance of the antigen originally responsible for it. It would be a highly significant fact if a transient exposure to antigen in fœtal life could confer a permanent or very long-lasting tolerance; but in our present experiments there is no reason to doubt that at least some of the cells of the fœtal inoculum survived as long as the tolerant state which they were responsible for creating. At all events, any complete theory of antibody formation must be competent to explain two sets of facts: that although embryos do not make antibodies, they respond to antigens in a manner that prejudices their ability to do so in later life; and that acquired tolerance is highly specific, for antibody-forming cells can be prevented from responding to one antigen without impairing their capacity to respond to any other.

A state of tolerance similar in principle to that which we have described may not necessarily depend upon an exposure to antigens in fœtal life. Phenomena which occur in adult life and which may be cognate with tolerance induced by fœtal inoculation include: (*a*) the highly specific 'immunological paralysis' of mice by the administration of relatively high doses of pneumococcal polysaccharide, made clear by the important experiments of Felton[2]; (*b*) that restraint of certain drug allergies in guinea pigs which, so Chase[13] has shown, may be brought about by the oral administration of the sensitizing chemical—an observation of particular interest, in view of the affinity between transplantation immunity and sensitization reactions of just this type[14]; and (*c*) the enhancement of the growth of tumour homografts by treatment of their prospective hosts with a variety of lyophilized tissue preparations, revealed by the work of Casey, Snell, Kaliss and their colleagues[15]. The relationship between these various phenomena has yet to be determined. We propose to investigate the hypothesis that exposure of the adult antibody-forming system to what may be called a 'tissue hapten' preparation—that is, to tissue ingredients which, although not themselves antigenic, contain the determinant groupings that confer specific activity upon complete antigens—may have the same kind of effect as that produced by an exposure of the immature antibody-forming system of the fœtus to complete antigens.

Actively acquired tolerance may not be a wholly artificial phenomenon. We are inquiring into the possibility that it may occur naturally by the accidental incorporation of maternal cells into a fœtus during normal development.

In dizygotic twin cattle of unlike sex, the confluence of fœtal vessels that leads to red cell

chimærism[3] and tolerance of homografts[6] has long been known to be associated with infertility of the female. In our present experiments, tolerance has been conferred upon female mice by inoculation with male cells without affecting their fertility. The two phenomena are therefore separable, although in cattle they go together and share an anatomical pre-requisite in common; but this is an inference that leaves entirely open the question of whether or not the freemartin state is due to a purely humoral influence of the male fœtus upon its synchorial female twin.

The experiments described in this article will in due course be reported on in full.

Summary

(1) Mice and chickens never develop, or develop to only a limited degree, the power to react immunologically against foreign homologous tissue cells with which they have been inoculated in fœtal life. Animals so treated are tolerant not only of the foreign cells of the original inoculum, but also of skin grafts freshly transplanted in adult life from the original donor or from a donor of the same antigenic constitution.

(2) Acquired tolerance is immunologically specific: mice and chickens made tolerant of homografts from one donor retain the power to react against grafts transplanted from donors of different antigenic constitutions.

(3) Acquired tolerance is due to a specific failure of the host's immunological response. The antigenic properties of a homograft are not altered by residence in a tolerant host, and the host itself retains the power to give effect to a passively acquired immunity directed against a homograft which has until then been tolerated by it.

(4) The fertility of tolerant mice is unimpaired.

[1] Cf. Rawles, M. E., *Physiol. Rev.*, **28**, 383 (1948).
[2] Felton, L. D., *J. Immunol.*, **61**, 107 (1949).
[3] Owen, R. D., *Science*, **102**, 400 (1945). Owen, R. D., Davis, H. P., and Morgan, R. F., *J. Hered.*, **37**, 291 (1946). Stone, W., Stormont, C., and Irwin, M. R., *J. An. Sci.*, **11**, 744 (1952).
[4] Dunsford, I., Bowley, C. C., Hutchison, A. M., Thompson, J. S., Sanger, R., and Race, R. R., *Brit. Med. J.*, **ii**, 81 (1953).
[5] Anderson, D., Billingham, R. E., Lampkin, G. H., and Medawar, P. B., *Heredity*, **5**, 379 (1951). Billingham, R. E., Lampkin, G. H., Medawar, P. B., and Williams, H. Ll., *Heredity*, **6**, 201 (1952).
[6] Cannon, J. A., and Longmire, W. P., *Ann. Surg.*, **135**, 60 (1952).
[7] Billingham, R. E., Brent, L., Medawar, P. B., and Sparrow, E. M. (unpublished work).
[8] Billingham, R. E., Brent, L., and Medawar, P. B. (unpublished work). The passive transfer of transplantation immunity was first demonstrated by Mitchison, N. A., *Nature*, **171**, 267 (1953); *Proc. Roy. Soc.*, B (in the press).
[9] The principle underlying this test was formulated by Chase, M. W., Abstr. 49th Gen. Meeting Soc. Amer. Bacteriol., 75 (1949).
[10] Billingham, R. E., and Medawar, P. B., *J. Exp. Biol.*, **29**, 454 (1952).
[11] Burnet, F. M., and Fenner, F., "The Production of Antibodies" (Melbourne, 1949).
[12] Burnet, F. M., Stone, J. D., and Edney, M., *Aust. J. Exp. Biol. Med. Sci.*, **28**, 291 (1950).
[13] Chase, M. W., *Proc. Soc. Exp. Biol. Med.*, N.Y., **61**, 257 (1946).
[14] Mitchison (ref. 8). Medawar, P. B., Colloquia of the Ciba Foundation (in the press).
[15] Summarized and reviewed by Snell, G. D., *Cancer Res.*, **12**, 543 (1952).

TRANSMUTATION OF THE ELEMENTS

TRANSMUTATION of the elements, once the dream of the alchemists, is now being carried out as an everyday operation in the laboratory and on the industrial scale. The present situation and its implications, especially in so far as they concern chemistry, were reviewed in a group of three papers given before Section B (Chemistry) of the British Association at Liverpool on September 8.

In the introductory paper, Dr. R. Spence (Atomic Energy Research Establishment, Harwell) showed how transmutation is occurring continuously due to the radioactive decay of the naturally occurring radioactive elements on one hand and to the absorption of cosmic radiation by the atmosphere on the other. In the case of uranium minerals, in addition to the normal decay series the spontaneous fission of the isotope uranium-235 leads to the production of neutrons, some of which are captured by the uranium-238 isotope, which decays through neptunium-239 to plutonium. Seaborg and collaborators at the University of California have identified extremely small amounts of plutonium (~ 1 part in 10^{14}) in carnotite. Cosmic-ray neutrons react with the nitrogen of the atmosphere to give carbon-14 and to a smaller extent to give hydrogen-3. On the basis of data given by Libby and co-workers at the University of Chicago, it has been calculated that 16 mgm. of radiocarbon are produced in the earth's atmosphere every minute.

The development of particle accelerators and later of the chain-reacting pile has provided us with the means of bringing about transmutations on a comparatively large scale. If the construction of nuclear reactors for the generation of electrical power proceeds as might be expected, it is quite likely that at least one ton of fissile material will be consumed in Britain per annum by 1970. World consumption might conceivably be as much as 100 tons per annum by the end of the century. The long-term future is very much dependent, however, on the successful transmutation of naturally occurring thorium or naturally occurring uranium into the fissile isotopes uranium-233 and plutonium-239, respectively, on an industrial scale. In this way the whole of the natural uranium and thorium supplies could be utilized as nuclear fuel instead of less than 1 per cent of the natural uranium as at present.

Besides the isotopes uranium-233 and plutonium-239, other isotopes of the heavy elements are produced in nuclear reactors, such as neptunium-237, americium-241 and curium-242. These were discussed in more detail by Dr. R. Hurst in the last of the three papers of the symposium. Since fission of 100 tons of nuclear fuel yields about 100 tons of fission products it is important that some effort should be made to utilize this material. The fission products consist of isotopes of elements in the middle of the Periodic System, from zinc to gadolinium. Work is going on both in the United States and in Britain to develop uses for the radiation from fission products such as for the preservation of meat and other foods, for sterilization of pharmaceuticals, for production and treatment of plastics and for bringing about chemical reactions. The fission products also contain the elements technetium and promethium, which do not occur in Nature. It is conceivable that some use will be found for these elements in due course and also for the inert isotopes arising from total decay of the active species.

The second paper, given by Dr. K. Chackett (University of Birmingham), dealt with transmutation induced by accelerated particles. The Bohr

theory of nuclear reactions forms a useful basis for understanding the nature of the products of such reactions and also how their yield varies as a function of the energy of the bombarding particle. The cyclotron has been commonly used for the production of radio isotopes by bombardment; but there are severe restrictions on the form of target material which can be used. For example, the heat transmitted to a small area of an internal target can amount to several kilowatts. This means that only high melting point metals can be used unless the beam intensity can be reduced well below the maximum available, and that some method of cooling may be needed. Liquids can be irradiated externally, but a window is required to admit the beam on account of the fact that cyclotrons have almost always been constructed to give horizontal radiation. Examples were quoted of isotopes which can be made by means of the 60-in. cyclotron which cannot be obtained from piles. As the product of the bombardment is usually an element different from the target element, it can generally be obtained 'carrier-free'.

Very recently, the University of Birmingham 60-in. cyclotron, in common with some other similar machines, has been used in novel ways for accelerating heavy ions such as $^{12}C^{6+}$, $^{13}C^{6+}$, $^{14}N^{6+}$, $^{15}N^{6+}$ and $^{18}O^{6+}$ to energies in the region of 100 MeV. At least twelve different radioactive species have been obtained, for example, from the bombardment of aluminium. It has been known since 1951 that bombardment of uranium with $^{12}C^{6+}$ ions yields isotopes of the heaviest known element, californium ($Z = 98$). One of the objects of the present work at Birmingham is to see whether this work may be extended by the use of heavier bombarding particles to the production of new elements beyond californium.

Present-day researches in nuclear physics are largely concerned with obtaining particles of higher energy than can be achieved with cyclotrons. The reactions induced by protons, deuterons and alpha-particles of several hundred MeV. given by the 184-in. synchrocyclotron at Berkeley have been studied by radiochemical means. In these reactions the bombarding particle ejects several particles from the target nucleus, a process known as spallation. A simple case appears to be the production of magnesium-28 by the reaction $^{30}Si(p,3p)^{28}Mg$. This magnesium isotope has a half-life of 22 hr. and might be a valuable tracer. Although, in general, high-energy machines are unsuitable for production of radioisotopes on account of the low beam current, the high-energy proton process has some advantages over the cyclotron in this particular instance.

Even higher energies are available from synchrotrons as opposed to synchrocyclotrons; thus the Birmingham proton synchrotron has recently been put into operation and gives protons up to 1,000 MeV. The main interest in particles of such extremely high energy is in the production of mesons; but there can be little doubt that results of radiochemical interest will also be obtained in spite of the much smaller beam currents given by such machines.

The final paper of the session was given by Dr. R. Hurst (Harwell). He pointed out that bombardment with high-energy charged particles yields at most only a few micrograms of product. It is only in the chain-reacting pile where very large quantities of neutrons can be generated and absorbed that transmutation can be brought about on a large scale. In addition to the production of plutonium in natural uranium piles, as described in the first paper, a number of isotopes of other heavy elements are produced although in much smaller quantities. For example, a long-lived isotope of neptunium (half-life 2×10^6 years) is produced by the reaction $^{238}U(n,2n)^{237}U \xrightarrow{\beta} {}^{237}Np$. A small quantity has been isolated at Harwell, and a sample containing a few milligrams was shown. Plutonium also absorbs neutrons and undergoes the following successive reactions: $^{239}Pu(n,\gamma)^{240}Pu(n,\gamma)^{241}Pu(n,\gamma)^{242}Pu$. These isotopes are all long-lived α-emitters except plutonium-241, which undergoes β-decay with short half-life to give americium-241, an isotope of element 95. So far, only a few hundred milligrams have been separated from plutonium. Americium can also be irradiated with neutrons to give americium-242, which decays by β-particle emission to give curium-242 (element 96), which has been isolated in milligram quantities.

The study of the chemistry of these elements has yielded results of considerable theoretical interest. From their place in the Periodic System it might have been expected that they would resemble the transition elements. In fact, the metals are base, not noble, the oxides are refractory, the halides are slightly volatile, and the ions tend to be simple rather than complex. The properties parallel, to some extent, those of the rare earths. Chemical studies, X-ray spectra, absorption spectra and determinations of magnetic susceptibilities all lend support to the theory that an inner 5*f* electron shell is being built up as one proceeds up the so-called actinide series, similar to the building up of the 4*f* shell in the case of the rare earths. The magnetic susceptibilities of a large number of compounds of the actinide elements have been determined at Harwell, and it has, in fact, been found that U^{IV}, Pu^{III}, Pu^{IV}, PuO_2^{++}, Am^{III} are paramagnetic ions obeying the Curie–Weiss law.

The solution chemistry of these elements is also of considerable interest and reaches the highest degree of complexity in the case of plutonium, where all four valence states (III, IV, V and VI) can co-exist in solution.

The mechanism and kinetics of the reactions between these various species have been worked out in considerable detail, but are not yet fully understood.

The possibility of the synthesis of still heavier elements, beyond californium, was mentioned in the second paper. Seaborg and collaborators at the University of California have made a systematic study of more than a hundred α-emitters in the heavy element region, and it is now possible to predict both chemical and radioactive properties of elements beyond californium with reasonable certainty. It is expected that $^{253}99$ will have a half-life of the order of days, and $^{252}100$ a half-life of perhaps a few hours. Chemical separation would, therefore, be possible; but the cross-sections for the formation of such isotopes as well as the presence of competing reactions become increasingly unfavourable.

As the atomic energy industry develops, supplies of the heavier actinide elements will increase and it is likely that new and unexpected uses for them will arise. A mixture of plutonium and beryllium, for example, provides a practically permanent source of neutrons without the troublesome γ-radiation which is emitted by radium–beryllium sources. Americium has an abundant 59-KeV. X-ray, and a few milligrams have already been used experimentally at Harwell as a special radiographic source. R. SPENCE

IMPORTANCE OF TITANIUM AND ITS ALLOYS IN ENGINEERING

A PAPER entitled "Titanium—a Metal of Engineering Importance?" was read on September 8 by Major P. L. Teed before Section G (Engineering) at the recent British Association meeting in Liverpool. The paper provides a clear picture of the possibilities of this metal, titanium and its alloys, in engineering, particularly in the field of air transport. Approximate mechanical properties of commercially pure titanium and of its alloys are as follows:

	Commercially pure titanium	Titanium alloys
0·2 per cent proof stress	34 tons/sq. in.	36–71 tons/sq. in.
Ultimate stress	39 tons/sq. in.	49–90 tons/sq. in.
Elongation	23 per cent	19–6 per cent

As with alloy steels, the room-temperature notched-bar impact resistance of the titanium alloys tends to decrease with increase in tenacity. A wrought, commercially pure titanium bar may, at room temperature, have a Charpy notch-bar value exceeding 50 ft. lb., while that of many of the stronger alloys may not, under similar conditions, absorb as much as 10 ft. lb.

As regards fatigue, at room temperature and employing standard test-pieces that are unnotched, the resistance of titanium and its alloys is impressively high—there can be little doubt that on the basis of ten million reversals of stress, this exceeds 50 per cent of the ultimate static tensile stress of the material. With regard to notched specimens, however, a less happy report has to be made. The impression arising from the work which has been done is that the metal and its alloys are much more notch-sensitive than alloy steels of the same static strength. Further, there is some evidence to show that, as the stress concentration factor is increased, the endurance is reduced to a considerably greater extent than would be the case with steels having similar static mechanical properties.

Titanium alloys, like those of other metals, are heat-sensitive. Above 100° C. and under comparable conditions, they have better specific mechanical properties than the wrought aluminium alloys; but at temperatures in excess of 400° C. those of several ferrous and non-ferrous alloys are superior to the best of the titanium ones, and above 800° C. hydrogen, nitrogen, oxygen, steam, carbon monoxide and carbon dioxide react vigorously with the hot metal.

Before leaving the mechanical properties of the metal and of its alloys, one troublesome defect must be mentioned. Both have quite deplorable frictional properties, and the metal is inclined to 'pick up', not only on itself but also on any other on which it is rubbing. It is possible, however, that some type of surface finish may be discovered which will overcome this difficulty.

So far as the chemical properties of the materials are concerned, it is already clear, although further work is required in more than one direction, that titanium and its alloys are resistant to a remarkable degree. Since this applies to sea water, even at temperatures up to those experienced in a steam condenser, titanium is a material of very definite interest to the marine engineer.

At present, though not necessarily for all time, really satisfactory castings cannot be made in titanium or its alloys, since all the materials which have so far been used for the moulds have been found to be attacked in varying degrees by the molten metal. Even should this difficulty be solved, the production of such castings will still prove difficult. The molten metal combines with vigour with so many gases that special melting and casting techniques would appear to be essential.

This intense chemical activity requires that titanium and its alloys should be forged in the temperature-range 880–980° C., and again, unless the heating is carried out in an inert gas, scale will be formed, which tends to reduce the life of the dies. Some of the two-phase alloys are subject to marked grain growth, necessitating quicker heating and a heavy reduction per heat, while subsequent heat treatment to bring about phase transformations may also be beneficial. The hot extrusion of the materials, given suitable die lubrication, presents little technical difficulty, and one most interesting lubricant suitable for these metals is molten glass. Cold drawing, if the metal is covered with a thin film of scale, presents few difficulties; but if the scale coat is inadequate, pick-up will occur.

The welding of titanium and its alloys must be carried out under conditions which prevent chemical reaction between the hot, or molten, metal and the surrounding atmosphere, and the helium or argon arc becomes ideal. Due, however, to the surface embrittlement which results when the materials are heated in air, the whole of the hot metal must be enclosed in an inert atmosphere, inert gas being fed to both sides of the weld during the operation. With commercially pure titanium and with the single-phase alloys, such modified helium- or argon-arc techniques produce extremely good welds, having an ultimate tensile strength and ductility of the same order as that of the basis metal. In the case of the two-phase alloys, however, although the tensile strength of the weld is satisfactory, the ductility is normally disappointing.

The machining of these materials still presents difficulties, and the best tool materials, cutting speeds, lubrication, etc., are still far from being satisfactorily determined. Commercially pure titanium can be deep-drawn to about the same extent as a low-carbon steel, but more frequent annealing is required and lower press-speeds. With the alloys of titanium, greater difficulties are experienced as their tensile strength increases, but a comparatively small increase of temperature, say, to 250–350° C., will greatly facilitate the more difficult press operations.

The second half of Major Teed's paper was devoted to a detailed consideration of the effect of the substitution of titanium in appropriate aircraft parts. Despite the high cost of the metal, varying from £3·5/lb. for hot rolled rods to £5·3/lb. for annealed sheet, its high mechanical properties and relatively low density suggest that by such 'titanizing' the disposable load of a machine at present having a basic equipped weight of 70,000 lb. could be increased by about 1,550 lb. or, alternatively, that in the design of an aircraft with a given disposable load such uses of titanium would result in a slightly smaller machine with certain ancillary advantages.

In Major Teed's view the question contained in the title of his paper—even at its present price—can be answered in the affirmative. Titanium and its alloys will have applications in mechanical, aeronautical and, possibly, marine engineering, and, as the price falls, the field of utility will surely widen.

KUMASI COLLEGE OF TECHNOLOGY, GOLD COAST

By Dr. J. P. ANDREWS
Principal of the College

THE Kumasi College is one of those Colonial regional colleges the development of which is fostered by the Advisory Committee for Colonial Colleges of Arts, Science and Technology. It came into legal being on October 6, 1951, provided with a mercifully simplified name. Development since then has been rapid, and 430 students were in residence in June 1953. This number is expected to rise to more than 700 by January 1954.

The site of the College is a tract of tropical forest about four miles from Kumasi, the capital of Ashanti. It was acquired through the generosity of the Asantehene, Sir Osei Agyeman Prempeh II, and consists of about four square miles of small hills and valleys, originally hidden in dense jungle.

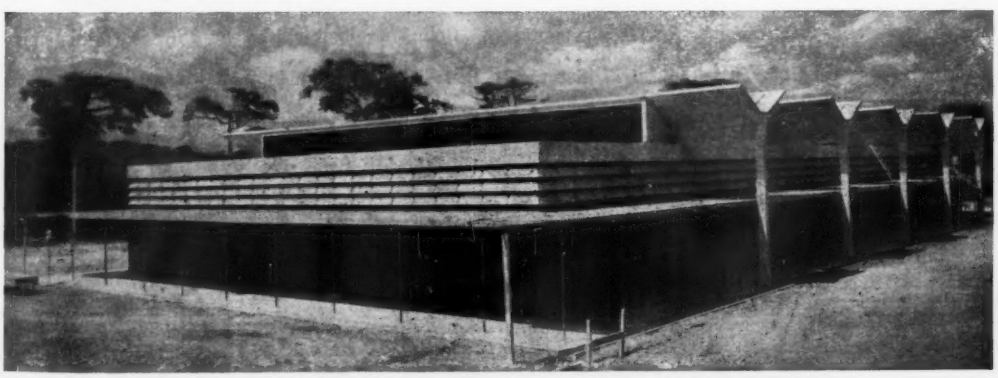
The College began with the transfer to the new site at Kumasi of the Achimota Teacher Training College, under its rector, Lord Hemingford, who became the first head of the Teacher Training Department of the new College. For this transfer a considerable area was cleared, and a large number of frame buildings of prefabricated type was erected during 1951, thus enabling the new College to open in January 1952 with some two hundred teacher-training students in residence, with the appropriate organization.

During the eighteen months since then, major buildings, designed by Messrs. Cubitt, Scott and Partners, have been under construction and are nearing completion. Indeed, the first section of the engineering workshops has been in use for instructional purposes since November 1952. The completion of the workshops, of the School of Pharmacy, and of a classroom block is anticipated this autumn. Houses for teaching staff have been constructed.

A major effort, with the expenditure of large funds on buildings and new equipment, has been made in the direction of engineering. The proposal is to run four-year courses in civil, mechanical and electrical engineering, courses in building (two years) and a course in surveying in preparation for the intermediate examination of the Royal Institution of Chartered Surveyors. Some twenty students distributed between the three branches of engineering have already completed one session. The objective in these courses is ultimately the graduate qualification of the professional institutions, negotiations with which have met with helpful response. A College diploma will also be available. It is possible that at a later stage permission will be sought to take the external degree of B.Sc. of the University of London; but the real need of the country at present is for training with a strong bias to the practical rather than the academic side of engineering. One of the greatest obstacles in the early years of training lies in the absence of the familiarity with mechanical things and ideas which an English boy acquires so readily. The first two years of the engineering courses therefore seek to supply the basic scientific knowledge and some familiarity with mechanical matters. The students enter after passing School Certificate, and wherever possible some experience in engineering or allied employment is demanded of the entrant. The staff of the department is being built up, and new machinery is flowing in and being installed. Prospects of the early completion of a well-equipped department, admirably housed and properly staffed, are excellent.

The staff and equipment of the School of Pharmacy, now operating in temporary quarters, were transferred from the Accra Hospital at Korle Bu, and when installed in the new building will be comparable with similar departments to be found in Britain. Pharmacy is a popular subject in West Africa; but so far, standards have been considerably lower than those in Britain. The Gold Coast Pharmacy and Poisons Board has recently taken steps towards improvement. One of these steps is the recognition of the College four-year course.

In addition to teacher training, engineering and pharmacy, Departments of Commerce and Agriculture have been set up, and already have students. In commerce the chief courses are accountancy and secretarial, covering the requirements of the chief accountancy bodies and of the Chartered Institute of Secretaries. The Agriculture Department is in the delicate position of being one of three bodies in the Gold Coast which provide training, namely, the Government Department of Agriculture, the Department of Agriculture of the University College of the Gold Coast, and the parallel department of the Kumasi College. By general agreement the functions of Kumasi College will be to train teachers of rural science, to give basic agricultural science to students in the Government Training School, and to carry out



The first section of the engineering workshops of the Kumasi College of Technology

research on the production of soft food crops—a species of market-gardening which has been much neglected in the Gold Coast. In addition, a course of one year's duration is given to train instructors of mechanized agriculture.

A further department, in some respects foreign to the ultimate purpose of the College, is called the Department of Intermediate Studies. This Department was organized initially, at the request of the Government, to fill the gap left by the absence of a sixth form in a number of secondary schools. The students in the Department read for Higher School Certificate, both in arts and science; and the majority of them apply for entrance to the University College. The Department fulfils, however, the further function of providing basic science for students of pharmacy, engineering and agriculture.

All students in the College at present spend some of their time in studying English, and a large proportion take mathematics. A Department of Mathematics and an organization under a senior lecturer in English have therefore been set up. Students, teaching staff and many of the administrative staff are resident on the compound. It follows that when the student population exceeds a thousand, with perhaps a hundred teaching staff and a large population of administrative and estate employees, the College will amount to a small town, with its own services, electricity, water, gas, its own roads and transport system. Already the pre-occupations of the administration tend to resemble those of a small town council.

Continued progress at the present rate is unlikely, but may still be rapid. It is a question whether funds from the Gold Coast Government will be forthcoming in satisfactory amount for a sufficient length of time. The shortcomings of the Ordinance, which appears to have been modelled on that of Achimota School, are beginning to be felt. Autonomy, which is incorporated in the Ordinance, tends to be nullified by the close dependence on funds provided by the Government, and the absence, as yet, of a quinquennial or triennial grant. Nevertheless, the essentials of a great College already exist, with far-reaching effects on the prospects for successful self-government in the Gold Coast.

OBITUARIES

Dr. Colin Campbell

Dr. Colin Campbell, dean of the Faculty of Science and assistant director of the Chemical Laboratories in the University of Manchester, died at his home on August 23. He entered the University, in which he spent his whole career, from William Hulme's Grammar School, Manchester, in 1906 and, after graduating with first-class honours in chemistry, was appointed Schunck research assistant to Prof. H. B. Dixon, with whom he published accounts of investigations on the velocities of explosions in gases, and on the velocity of sound in, and the specific heats of, gases at high temperatures.

During the First World War, Campbell was a member of Dixon's team of inspectors of explosives under the Ministry of Munitions. Afterwards, with a succession of collaborators, using mainly photographic methods, he continued to study the velocities of gaseous explosions with particular reference to the changes arising as explosions pass from one tube to another of different diameter or through successive tubes of glass and rubber, to the influence of dilution by inert gases and also to the initiation of explosion in one gaseous mixture by an explosive wave from another. Many of these investigations involved ingenious developments of technique, as did his work on the determination of pressures developed in the combustion of gaseous mixtures; but perhaps the most elegant experimental work followed the observation, with D. W. Woodhead, of striations in the photographic records of explosion waves in carbon monoxide–oxygen mixtures (1926). Campbell and Woodhead carefully investigated this phenomenon, and Campbell and A. C. Finch, two years later, established that it is accounted for by the helical path followed by these explosions in a tube.

Dr. Campbell became a member of the staff of the Chemistry Department in the University of Manchester in 1914 and senior lecturer in 1925. He played an important part in the teaching in the Chemistry Department, and his experimental lectures, characteristic of his personal qualities, were models of lucidity and precision. He was in continual demand as a lecturer to more general audiences outside the University. Many generations of students quickly came to value his skilful and patient teaching in the first-year laboratory.

As assistant director of the Chemical Laboratories from 1935 his activities embraced a much wider field. His influence in maintaining a unified department, through a period of considerable change, cannot be over-estimated. He was the faithful guardian of a great departmental tradition. Eminently approachable, his friendly manner and spontaneous interest gained him the confidence of both colleagues and students, with whom he established close personal contacts. He was usually the first to learn of a student's personal problems, and those in difficulty, including disappointed examinees, were always certain to receive sympathy and encouragement to further effort. The meeting of the University Chemical Society last year, at which he gave his presidential address reviewing the history of the Department, was a memorable occasion. He was an influential member of the Board of the Faculty of Science for many years and was appointed dean in 1952.

Manchester's religious life will be greatly impoverished by his death. He gave a life-time of devotion to the Congregational Church in the area, to the Manchester and Salford Shaftesbury Society and particularly to his own Cavendish Congregational Chapel, of which he was secretary, Sunday school superintendent and often organist.

Colin Campbell will be sadly missed in his University and in many walks of life outside its walls; but he leaves behind indelible and happy memories of his deep and sincere Christianity, strong human sympathy, warm friendliness, modesty and wise patience. It is as an unfailing friend that so many will continue to think of him.

E. R. H. Jones
G. Norman Burkhardt

We regret to announce the following deaths:

Prof. A. F. Holleman, formerly professor of chemistry in the Universities of Groningen and Amsterdam, on August 11, aged ninety-three.

Dr. E. P. Hubble, of Mount Wilson Observatory, associate of the Royal Astronomical Society, on September 28, aged sixty-three.

NEWS and VIEWS

Chemistry at Durham : Prof. F. A. Paneth, F.R.S.

Prof. F. A. Paneth, on reaching the retiring age this autumn, terminates his highly successful activities as professor of chemistry and first director of the Londonderry Laboratory for Radiochemistry in the University of Durham, and is going to Mainz as director at the Max Planck Institute for Chemistry. In the early years of this century, Sir William Ramsay addressed an audience in Vienna. The large and enthusiastic gathering listening to his fascinating report of the discovery of the noble gases included the great landowner Kuppelwieser, who was so much impressed by Ramsay's lecture that he decided to finance the costs of an institute for radioactive research to be erected by the Vienna Academy of Sciences. Paneth, who had just taken his degree in chemistry in the University of Vienna, joined this institute as an assistant and contributed very materially to the important work carried out in the course of the first decade of its activities. This included numerous pioneer investigations on the application of radioactive indicators in inorganic and physical chemistry. In 1913 Paneth spent some time in Soddy's laboratory in the University of Glasgow, where one of his activities was the study of methods of microanalysis of gases which he later developed to a most remarkable extent. The first fruit of his great skill in analysis of gases was the discovery of polonium hydride, followed by the discovery of lead, bismuth and tin hydrides and of free organic radicals. In recent years he has made very important contributions to our knowledge of the composition of the higher atmosphere and of the helium content of meteorites as an indication of their age. Simultaneously, he has promoted several branches of radiochemistry.

Intense and most successful occupation with numerous experimental problems did not prevent Paneth from being a most effective first president of the International Commission of Radioactivity. Nor did it prevent him from showing much interest in the definition of fundamental concepts of chemistry and in the study of the history of science. This is witnessed by his publications on the life and works of Boyle and his remarkable lecture on Thomas Wright of Durham and Immanuel Kant. Prof. Paneth has shown himself to be an ingenious experimenter, a scholar and an eminent teacher.

Prof. G. E. Coates

Prof. Paneth is being succeeded at Durham by Geoffrey Edward Coates, son of J. E. Coates, the retired professor of chemistry in the University College of Swansea (University of Wales). Prof. Coates, who was born in 1917, was educated at Clifton College and Queen's College, Oxford, where he obtained the degrees of B.A. (first-class honours in chemistry) and B.Sc. During the Second World War he did research work on corrosion at the Metallurgical Research Laboratories of the Magnesium Metal Corporation, Swansea. Since 1945 he has been lecturer in inorganic chemistry in the University of Bristol; he has acted also as chief examiner in chemistry to the Bristol University School Examination Board. In December 1952 he was appointed senior reporter for inorganic chemistry for the "Annual Reports of the Chemical Society", and for the past five years he has been consultant to the Imperial Smelting Corporation, Ltd., Avonmouth. He is also a member of the Bond Energy Committee and the Fuel Incendiary Panel (Ministry of Supply, Scientific Advisory Council). Prof. Coates's publications before the War dealt with electrochemical problems: the electrolytic corrosion of metals, electrode potentials, and polarization; but some were also concerned with questions of molecular structure. Since the War, he has devoted his efforts mainly to the study of organometallic compounds (for example, trimethylgallium and dimethylberyllium), of borine derivatives, and of fluorine compounds.

E. R. Cooper Memorial Award for Work in New Zealand

In memory of the late Dr. E. R. Cooper, a fund is being raised to institute an annual award to scientific workers. Dr. Cooper, who died a year ago at the age of forty-two, was one of New Zealand's younger scientists. His death was a serious loss to scientific research, organization and administration. For a decade he guided the development of the Dominion Physical Laboratory, which, beginning with a very small physics section, became under his directorship the largest branch of the N.Z. Department of Scientific and Industrial Research. Besides his capacity as an organizer, he possessed outstanding scientific qualities. He always attached great importance to the publication of scientific work and the development of the natural resources of New Zealand. These two ideas have been incorporated in a memorial award sponsored by the Dominion Physical Laboratory Technical Advisory Committee of the Council of Scientific and Industrial Research, and the Department of Scientific and Industrial Research, New Zealand. The award will be made annually to the author or authors of published physics or engineering papers who give the best account of their research work in New Zealand, preference being given to work that contributes to the development of the natural resources of that country. The Royal Society of New Zealand will administer the award, and will appoint a selection committee consisting of two representatives of the University and two of the Royal Society of New Zealand, and one of the Department of Scientific and Industrial Research. Donations towards the capital sum required to establish the award should be sent to the Secretary, D.S.I.R., P.O. Box 8018, Government Buildings, Wellington. While the monetary value of the award will be small, its scientific standing will be high and in accord with the high standard set by the scientist whose memory it perpetuates.

Commonwealth Fund Fellowships for Advanced Study and Travel in the United States

A number of Commonwealth Fund Fellowships are again being offered by the Commonwealth Fund of New York to British subjects for study and travel in the United States. All expenses of travel, study and living will be met, with some adjustment of stipends for married men. The Fellowships, which are open to British men and women who are not normally resident in or near the Americas and who have not previously worked or studied for more than a few months in the United States, are offered annually in six categories as follows. *General:* twenty Fellowships to graduates of a university in Great Britain and Northern Ireland; candidates

must be available in London for interview in March 1954; age 23–32; tenure, 12–21 months; applications by December 15. *Home Civil Service:* five fellowships to permanent members in the higher ranks of the Civil Service in Great Britain, three for the administrative grades and two for the scientific and professional grades; age, less than 40; tenure, 6–12 months; applications by December 31. *Dominion Civil Service:* five fellowships to Civil servants in the Governments of Australia and New Zealand; age less than 40; tenure, 9–15 months; applications by November 1. *Colonial Civil Service:* two Fellowships to Civil servants in the Governments of British Colonies, Protectorates and Trust Territories; age, less than 40; tenure, 6–12 months; applications by November 16. *Journalism:* three fellowships to journalists, practising in the United Kingdom and engaged on the opinion-making or broadly editorial side of their profession; age, 23–35; tenure, 9–15 months; applications by December 31. *American Studies:* four Fellowships to faculty members appointed to or holding posts in American studies in universities in the United Kingdom; candidates to be nominated by their universities; tenure, 4–12 months (these Fellowships are not limited by previous study in the United States). Application forms and further details of these Fellowships can be obtained through British universities or through Government departments, or from the Warden, Harkness House, 35 Portman Square, London, W.1.

Controlled Leaf Morphogenesis

By growing plants of *Marsilea* in aseptic culture media of known composition, A. Allsopp (*Ann. Bot.*, N.S., **17**, 65, 37; 1953) has shown that the leaf shape can be controlled. In plants with the characteristic tetrafid adult leaves, reversion to simple bifid or awl-shaped juvenile leaves was obtained by depriving the cultures of either sugar or mineral nutrients. There was also a concomitant reduction of the solenostele to a protostele. Comparable results were obtained by using the excised apices of rhizomes or their lateral branches. These results are of particular interest in relation to the general problem of heteroblastic leaf development—a phenomenon originally attributed by Goebel to nutritional factors but variously ascribed to other causes by different investigators. The main body of evidence supports Goebel's view; but the precise relation of nutrition to the regulated ontogenetic pattern of leaf development has never been elucidated. In a discussion of this problem, reference is made to the changing dimensions of the shoot apical meristem during the normal ontogenetic enlargement and under 'starvation' conditions. In most cases of heteroblastic development it is unnecessary to seek explanations in terms of special growth substances, physiological ageing, etc. In the individual plant the changing size of the apex under the influence of nutritional factors would seem to afford an adequate explanation.

The *Luffa* Plant and its Uses

The loofah of commerce, also known as the '*Luffa* sponge', 'dishcloth' or 'dishrag gourd', 'snake gourd' and 'vegetable sponge', is the cleaned, dried inner fibrous tissue of the fruit or gourd of *Luffa* spp., which grow readily in most warm countries. It is a climbing annual plant, and has been grown in Japan from olden times. The plant and fruits resemble cucumbers; but the fruits are fatter and hang heavily on the vines, while the stems are more woody and stronger. In Japan, the plant blooms during June–July, and the flowers last well into the autumn. The two most common species are *Luffa cylindrica*, to which belong the varieties cultivated in Japan for loofah production, and *L. acutangula*. Both species produce good fibre; but with *L. cylindrica* the fruits are bigger and more cylindrical in shape, and the fibres are of better quality. The best type of loofah for the commercial market is the one produced in Japan, where the soil and climate have proved well suited to their cultivation. An account of the loofah industry in Japan has been given by J. S. Ingram in *Colonial Plant and Animal Products* (**3**, No. 2). The cultivation and possibilities of the plant in Colonial territories is also described.

Bird Preservation

In 1950 a conference was held in Paris to discuss the revision of the international convention for the protection of birds useful to agriculture, which had been signed in 1902. The conference was attended by delegates from Austria, Belgium, Denmark, France, Greece, Netherlands, Portugal, Spain, Sweden, Switzerland, Turkey and the United Kingdom and, on behalf of their Governments, a new draft convention was signed *ad referendum* by all delegates. The full text of the convention is set out in the sixth bulletin of the International Committee for Bird Preservation, which has been prepared with sections in English, German and Spanish and may be obtained from the British Museum (Natural History), Cromwell Road, London, S.W.7. Besides the usual reports on bird protection in various countries, the bulletin also reviews the work of the International Wild Fowl Research Institute and gives full details of the legislation which has been adopted by member countries for the better preservation of wild fowl.

Philosophy for Management

A valuable guide for members of its supervisory staff has recently been issued by the Triplex Safety Glass Co., Ltd. The supervisory staff is taken to include the directors, senior staff and foremen; and, in a foreword, the chairman and managing director, Sir Graham Cunningham, suggests that the booklet will help them to become clear about the policy of the Company and about the human relationships involved in it. The booklet includes a chart showing the organization of the Triplex Group and short explanatory statements on such topics as the function of the board of directors, research and development, the meaning of profit, the reasons for the use of specialist departments, the role of the trade unions, the structure of wages, the value of suggestion schemes, accident prevention and personnel services. The booklet is written in a succinct and admirable manner, and the ideas contained in it might well be copied for use in other firms.

Endeavour

In the eleven years since it was first published by Imperial Chemical Industries, Ltd., the quality of the contributions to *Endeavour* has been at a consistently high level. It is doubtful whether any previous issue, however, could equal the quality of the articles appearing in the July issue of this journal. W. B. Alexander, for example, has written an admirable article on ornithological illustration which is sup-

ported by coloured plates of first-rate quality. In another article Sir Henry Dale discusses the transmission of impulses along muscle and nerve fibres and analyses the objections to theories of electrical conduction across cell-junctions. Dr. W. G. Palmer considers the basis of stereochemistry and its application to inorganic compounds, while Dr. D. Mackie contributes a useful biographical account of the French chemist who taught Lavoisier, Guillaume-François Rouelle. In an article on the evolution of adaptations, Prof. C. H. Waddington puts forward a hypothesis to explain how acquired characteristics may become hereditarily fixed by a process of genetic assimilation not invoking the generally discredited theory of direct inheritance. Prof. K. Mather examines the contribution of biometry to the growth of the inductive method, while B. W. Mott deals with progress in metallurgical microscopy. An interesting feature of this issue of *Endeavour* is the personal message of goodwill from the Duke of Edinburgh.

Directory of Sources of Specialized Information in Great Britain and Ireland

THE "Aslib Directory", published in 1928, was for many years the standard work on sources of specialized information in Great Britain and Ireland. It has been out of print for a number of years, and a new edition is now in course of preparation. The "Directory" should prove of great value to research workers and others in giving details of the chief collections of books and other material on specialized subjects and where they can be obtained. To cover as wide a field as possible, more than six thousand questionnaires have been sent to universities, colleges, technical institutions, public libraries, museums, research organizations, government departments, learned and specialist societies and commercial and industrial firms. Inevitably, some organizations which act as sources of information on certain specialized subjects may have been overlooked, and if they consider that they have a claim to be included in the "Directory", they should get in touch as soon as possible with the Director of Aslib, 4 Palace Gate, London, W.8.

National Science Foundation: Completion of Research Awards for 1953

THE National Science Foundation has announced the award of thirty-four research grants, amounting to about 208,000 dollars, which complete the total of grants made by the Foundation during the fiscal year 1953 for the support of basic research and related matters. During the year, the Foundation has made 292 awards totalling more than 2,151,000 dollars, and since the beginning of the programme in 1950 more than four hundred such awards have been made, totalling about 3,635,000 dollars. The fields included in the latest list are chemistry, earth sciences, environmental biology, genetic biology, molecular biology, regulatory biology, systematic biology, scientific information, scientific personnel information, and special studies in science. The duration of research grants in this group ranges from one to two years, with an average length of 1·3 years.

Rajasthan Academy of Sciences: Officers for 1953–54

AT the third annual meeting of the Rajasthan Academy of Sciences, the following officers were elected for the session 1953–54: *President*, Dr. P. Nilakantan, principal, Birla College, Pilani; *Vice-Presidents*, Dr. K. M. Gupta, professor of botany, Jaswant College, Jodpur, and Dr. A. K. Chatterji, vice-principal, Engineering College, Pilani; *Vice-Presidents* (who have held the office of president), Prof. M. L. Schroff, Calcutta, Dr. M. L. Roonwal, Dehra Dun, and Dr. G. S. Mahajani, Delhi; *Secretary*, Prof. K. Ramamurti, Rajasthan Academy of Sciences, Pilani, Rajasthan; and *Treasurer*, Shri. Roshan Singh.

International Union of Crystallography, 1954

As already announced, the Third General Assembly and International Congress of the International Union of Crystallography will be held in Paris during July 21–28, 1954. At the Congress, papers will be presented on all aspects of crystallographic research; there will also be an exhibition of crystallographic apparatus and books. After the Congress two specialized symposia will be held on "The Location and Function of Hydrogen" and "The Mechanism of Phase Transitions in Crystals", and there will be visits to localities of mineralogical interest. Full details of the meeting may be obtained from the General Secretary of the Union (R. C. Evans, Crystallographic Laboratory, Cavendish Laboratory, Cambridge, England), from the Secretary of the Programme Committee (A. J. Rose, Laboratoire de Minéralogie, 1 rue Victor Cousin, Paris 5, France) or from any of the following regional representatives of the Programme Committee: G. Menzer (Universitätsinstitut für Kristallographie und Mineralogie, Luisenstrasse 37/II, München 2, Germany), W. H. Taylor (Crystallographic Laboratory, Cavendish Laboratory, Cambridge, England), J. D. H. Donnay (The Johns Hopkins University, Baltimore, Maryland, U.S.A.). Offers of papers for the Congress and symposia and notice of enrolment must reach the secretary of the Programme Committee (preferably on the form accompanying the first circular) by February 15, 1954. All general correspondence should also be addressed to the Secretary of the Programme Committee.

Announcements

MR. W. J. C. LAWRENCE has been made acting director of the John Innes Horticultural Institution as from October 1, when the former director, Dr. C. D. Darlington, took up his post as Sherardian professor of botany in the University of Oxford (*Nature*, 171, 373; 1953).

DR. R. HOLROYD, a director of Imperial Chemical Industries, Ltd., will deliver the second Coal Science Lecture of the British Coal Utilisation Research Association on October 21 at 4.0 p.m. in the rooms of the Royal Society. He will speak on "Coal as a Source of Chemical Raw Material".

THE University of Chicago is offering three post-doctoral fellowships in statistics, worth 4,000 dollars, for the academic year 1954–55. The purpose of the fellowships, which represent the fourth year of a five-year programme supported by the Rockefeller Foundation, is to give established research workers in the biological, physical and social sciences the necessary training in modern statistical analysis for the planning of experiments and other investigations and in the analysis of empirical data. Further details pertaining to applications for these fellowships (which must be completed by February 15, 1954) can be obtained from the Committee on Statistics, University, Chicago 37.

ANALYSERS AND COMPUTERS FOR ELECTRICAL SYSTEMS

A VACATION school on analysers and computers for electrical systems was held in the Electrical Engineering Department of the Imperial College of Science and Technology, London, during the week July 13–17, and was attended by some sixty engineers drawn from industry, the British Electricity Authority, research associations, technical colleges and the universities. The purpose of the school was to encourage the wider use by electrical engineers of analysers and computers for solving the problems that arise in the fields of electrical machines, electrical control systems and power networks. In an opening address, Mr. F. J. Lane, transmission design engineer to the British Electricity Authority, stressed the value of vacation schools in providing opportunity for discussion and exchange of information, and referred to the continuing development of more accurate methods of calculating the design and performance of electrical systems.

The first lecture was by Mr. B. Adkins, of Imperial College, who described the course as an opportunity for electrical engineers to review recent improvements in the methods available for the solution of numerical problems with the aid of computers, analysers and models. He went on to discuss electrical machine problems, grouping these as design calculations and performance calculations, each group comprising routine calculations and research investigations, and showed some examples of each type. In the following lecture, Dr. J. R. Mortlock, of British Thomson-Houston Co., Ltd., Willesden, introduced some of the more common problems met in the design of power systems, showing the types of equation encountered in each and the usual methods of solving them. The third lecture, by Dr. J. H. Westcott, of Imperial College, dealt with the design of closed-loop control systems. A discussion of steady-state calculations and graphical methods using harmonic responses was followed by a survey of methods of estimating transient response with suggestions for applying more comprehensive criteria to the performance, and hence design, of control systems.

Dr. W. J. Gibbs, of British Thomson-Houston Co., Ltd., Rugby, opened the next section of the course with a lecture on the mathematics of the problems. He showed that problems first require formulation by the specification of an ideal system which can be represented in mathematical terms, and then reviewed the types of calculation often required. He demonstrated that matrices can assist the orderly arrangement and manipulation of performance equations of all types of system. The remaining lectures dealt with methods for solving equations of the types described by Dr. Gibbs.

In a lecture on "Systematic Computation", Mr. M. W. Humphrey Davies, of Imperial College, put forward suggestions for processes intermediate between simple slide-rule calculations and the complex methods used in automatic computers. After surveying existing types of hand-operated calculating machines, he demonstrated a convenient method for the solution of sets of linear simultaneous equations, and described an improved type of semi-automatic machine, designed for handling two-dimensional quantities, that is being constructed at Imperial College. He concluded by suggesting that semi-automatic machines might be specially suitable for many routine calculations.

On the evening of July 14 members of the school visited the laboratories at Imperial College and saw the automatic digital computers constructed by Dr. Tocher in the Mathematics Department and a transformer-analogue analyser, a semi-automatic decimal computer for complex quantities and other analogue devices in the Electrical Engineering Department. July 15 was spent at the National Physical Laboratory seeing the automatic computer (known as the ACE), the analogue differential analyser and the punched-card tabulating equipment in the Mathematics Division and an analogue device for the design of control systems in the Servo-mechanisms Laboratory.

Dr. J. M. Bennett, of Ferranti, Ltd., described several types of automatic digital computer and discussed the advantages of their rapidity and accuracy in dealing with different types of engineering problem. The lecture concluded with details of the method of handling typical problems. Mr. L. Gosland, of the Electrical Research Association, in a lecture on "Analogue Analysers" gave an extensive survey of analogue computers, network analysers, models and simulators, giving examples of their application to practical problems.

The final lecture, by Dr. G. R. Slemon, of Imperial College, was concerned with the solution of non-linear problems, confining itself to two methods of considerable generality: namely, numerical or step-by-step methods, and approximate steady-state methods using modified linear techniques. Finite difference methods were described for the solution of first-order, simultaneous and higher-order differential equations with variable parameters. Dr. Slemon then explained his 'fundamental frequency' approach to steady-state non-linear circuits and showed how this could be applied to both power-frequency and stability problems. Finally, adaptations of mathematical, graphical and other techniques for use with the fundamental-frequency method were surveyed.

The discussions that followed the various lectures and the general discussion at the end of the course showed that the vacation school had provided a useful meeting-ground for experts in various types of electrical design problems who had been able to exchange useful information concerning developments in the use of analogues and computers. It appeared that there would be considerable demand for the facilities of automatic computing machines as these become available and that there is scope for improvements in desk machines. It was felt that a desk computer with a trained operator would be a useful adjunct to many engineering offices, but that analogue rather than digital devices would often be preferred by engineers because explicit mathematical formulation of the problem is unnecessary and because such devices are frequently analogous to the physical system, with the added advantage in power network and similar problems that the general behaviour of the system can be observed directly. Such devices make it possible for the engineer to solve his own problems with only occasional assistance from a mathematician, and this was thought to be preferable to the use of external computing services.

MICROWAVE OPTICS

WITHIN the past two decades much research has been carried out on electromagnetic radiation of wave-lengths which belong to the transition region between the ordinary radio region and the optical region of the electromagnetic spectrum. Because of certain properties characteristic of this range, and also because the wave-lengths in this transition range are of the order of magnitude of most mechanical devices handled in laboratories, this new branch of electromagnetic theory, often called microwave optics, offers to physicists many interesting new opportunities. These are being well explored, for example, in connexion with communications and radar.

During the four days June 22–25, a symposium on microwave optics was held at McGill University, Montreal, under the joint sponsorship of the Eaton Electronic Research Laboratory, of Commission VI of the International Scientific Radio Union (U.R.S.I.) in Canada and the United States, and of the Electronic Research Directorate, Air Force Cambridge Research Center (U.S.A.). The symposium marked the scientific opening of the Eaton Electronic Research Laboratory, which now, in its third year of existence, is already playing a prominent part in this field of research, under the directorship of Prof. G. A. Woonton.

The main aim of the symposium was to bring together scientists who work not only on microwave optics but also on related subjects, such as light optics, information theory, operational methods, etc., thus enabling exchange of information and a closer collaboration between research workers in these fields.

The symposium was attended by about 140 scientists mainly from Canada and the United States and by seven guest speakers from Europe. During the four days, altogether sixty-four papers dealing with a wide range of subjects were presented. These numbers themselves indicate the great interest now shown in microwave optics. There were altogether eight half-day sessions on the following subjects: scattering (two sessions); microwave optical systems and aberrations; electromagnetic diffraction (two sessions); electromagnetism and diffraction; Fourier transforms and information theory; radio lenses, and other topics of special interest. In addition, there was a round-table conference on Fourier transforms, under the chairmanship of Dr. Roy C. Spencer, of the Air Force Cambridge Research Center. It is impossible in a short article to analyse the very extensive material presented at the symposium, and consequently only a brief account of the main subjects discussed will be given.

Papers presented in the session on scattering were mainly concerned with power series solutions of scattering problems, and with calculations and measurements of scattering cross-sections and radar cross-sections. Some integral-equation techniques were also described and applied to problems of diffraction by spheres, cones and wedges, subject to simple boundary conditions.

The session on microwave optical systems and aberrations began with a survey of some of the research carried out at the Naval Research Laboratory in Washington, and described investigations on microwave optical systems for use in radar scanning antennæ. Other papers were concerned with wide-angle focusing properties of paraboloidal mirrors, with applications of Rayleigh's tolerance criteria to microwave systems, and with the behaviour of the geometrical field near caustics. The ideal lens of Luneberg and its variants were discussed by several speakers in this session and also in the session on radio lenses. An interesting contribution to aberration theory was made in a paper concerned with characteristic curves in the image space, where a method was proposed for the derivation of functions orthogonal over parabolic and other domains; these should prove useful in certain theoretical investigations of diffraction.

In the session on radio lenses and other topics of special interest, an interesting account was given of some of the current researches carried out at the Ministry of Supply Telecommunication Research Establishment in Great Malvern; it dealt mainly with the use of optical techniques at millimetre wavelengths. Several papers discussed the behaviour of various artificial dielectrics.

The papers presented in the two sessions just mentioned indicated the similarity as well as the differences between systems employed in microwave optics and in light optics: microwave systems work as a rule with a smaller number of surfaces and larger numerical apertures; in microwave optics aspherical surfaces and asymmetrical combinations are the rule; in light optics they are the exception. In systems working with ordinary light the illumination is, as a rule, uniform; in microwave systems it is usually tapered.

Electromagnetism and especially electromagnetic diffraction were particularly well represented. Many of the contributions dealt with various aspects of diffraction by apertures in plane screens, and were followed by lively discussions. The theoretical papers were mainly concerned with approximate methods of solution, while those dealing with the experimental aspects described methods and results of measurements of diffraction fields. The literature of diffraction by apertures in plane screens is very extensive, and the comments from the audience indicated the difficulties faced by all but the experts on this class of problems when trying to assess the merits of the various methods of solution and the present state of knowledge in this field. The present writer shares the view expressed by some of the scientists taking part in the discussion, that a formal solution to a diffraction problem is often of relatively little value unless supplemented by computational data, and that a good deal more effort ought to be devoted to this end. (In this connexion it may be of some interest to mention that although Sommerfeld's classical solution of the half-plane problem was obtained as early as 1896 and numerous discussions of this problem have been published since, it was not until 1952 that detailed diagrams were given, showing the behaviour of the amplitude and phase and of the energy flow (Poynting vector) in the neighbourhood of the diffracting edge (W. Braunbek and G. Laukien, *Optik*, 9, 174 (1952); the diagrams bring out interesting features not previously suspected.)

Other papers dealt with asymptotic solutions (for large wave-numbers) of linear partial differential equations, with a new method (called 'cliff method') for approximate integration, and with the application of operational techniques to the development of diffraction integrals. Another group of papers was concerned with scalar treatment of diffraction problems and with the analogies between the field of geometrical optics and certain diffraction fields. A generalization of Fermat's Principle was suggested in

a paper entitled "The Geometrical Theory of Diffraction". A good deal of attention was given to a paper concerned with the 'creeping wave' in the theory of diffraction. It outlined a method for problems concerned with the diffraction by objects not larger than about a hundred wave-lengths; the asymptotic expansions can then no longer be used, as there may be a considerable contribution from a wave creeping around the back of the object.

As already mentioned, one session was devoted to Fourier transforms and information theory. Accounts of useful Fourier and operational techniques were given and various applications described. Some analogies between optics and information theory were noted. This session as well as the round-table conference on Fourier transforms suggest that Fourier transforms and information theory are likely to play an increasingly important part both in light and microwave optics.

On several occasions during the symposium, attention was directed to investigations in related subjects closely analogous to the work described, and it became apparent that there is a good deal of overlapping and repetition in the two main fields. But no one who was present in the crowded sessions at McGill could have departed without being stimulated by the variety of ideas and by the impressive record of work carried out in microwave optics during the past few years. The only criticism which may be raised refers to the fact that each speaker was allowed only 10–15 minutes, a period certainly not sufficient for the presentation of some of the subjects. It is, however, easy to understand the difficulties with which the organizers of any large scientific gathering are faced in this connexion. To some extent these difficulties were overcome at McGill by the distribution, prior to the opening session, of mimeographed volumes containing summaries of all the papers. An extended version of these volumes will shortly appear as a special issue of the *Canadian Journal of Physics* and will undoubtedly become an important contribution to the literature on microwave optics.

E. Wolf

CENSUS OF WOODLAND AREAS LESS THAN FIVE ACRES IN GREAT BRITAIN

THE first report of the census of woodlands in Great Britain, carried out during 1947–49, gave the statistics for the area and stocking of woodlands of five acres and more (see *Nature*, August 8, p. 240). The second report, which has now been published*, provides the additional data, collected during 1950–51, and completes the census in respect of all timber which could be included as forming part of the national resources available in time of need and of a reserve which, given reasonable care and management, will continue to grow and produce more timber. The relative importance of these small woods and scattered trees is not generally appreciated except by the few directly concerned, though the war-time (1942) survey had indicated that they carried something like one-fifth of the total timber volume in the country. The figure for hedgerow and park timber now arrived at for the whole of Great Britain is 807 million cubic feet and that for the small woods 222 million cubic feet, forming 21 and 6 per cent respectively of the total volume of 3,773 million cubic feet (this includes the large woods). Moreover, the average size of the trees in the hedgerows, parks and small woods is appreciably greater than that in the larger woods, this fact being largely ascribable to the concentration of war-time fellings on the larger woods and on the older crops in them.

Of particular interest in the present survey are the methods adopted for collecting the necessary field data and for computing the results with a measure of the probable errors involved. For the hedgerows and parks, the method already established in the 1938 and 1942 surveys was retained. It consisted in the field examination of a strip 44 yards wide, drawn on selected Ordnance Survey quarter sheets on the scale of six inches to a mile. The percentage of sampling is a very low one, one acre in roughly eight thousand, built up of three independent random sets of the Ordnance Survey maps. The standard error, as a percentage of the actual volume, is computed at 8·5 per cent; this is low enough for all practical purposes, though it does not permit of a reliable break-down of the figures into countries and conservancies—thus the standard error for Scotland alone would be 25 per cent.

As might be expected, the five common hedgerow species, oak, elm, ash, beech and sycamore, are found to constitute the bulk of the volume, about four-fifths of the total, oak with 34 per cent and elm with 19 per cent alone contributing half by number of trees and slightly more by volume. The prospects of maintenance of this resource by growth and recruitment are considered. It is thought that there are enough saplings to maintain the numbers of small hedgerow trees, but the distribution of size classes suggests that the volume of larger hedgerow timber is likely to diminish unless further planting (or storing) is carried out.

For the small woods, between one and five acres, the methods are much more closely linked with the survey of the large woods. Small woods were already known to aggregate 187,000 acres, about 5 per cent of the total woodland area. Again a sampling method was adopted, involving the field examination of small woods in the south-western quarter of each of the Ordnance Survey six-inch quarter sheets selected for the hedgerow census, in the same three samples. This worked out at an aggregate 0·92 per cent sample. These woods were classified into the same types as were differentiated for the large woods, and it is assumed that the average stocking per acre for each type is the same for both categories of size. The objections to this assumption—and they may well be viewed as rather serious—are recognized; but the considerable additional work involved in obtaining independent estimates was not felt to be justified. Since the surveys were made, 5 per cent of the area shown as small woods has been lost to other forms of land use, as compared with 2 per cent of the large woods: this reduces the total area to 178,000 acres comprising 71,730 woods fairly equally distributed between 1–2, 2–3, 3–4 and 4–5 acre units. The current annual growth or volume increment of the trees in these woods is estimated at 5 million cubic feet, to be compared with 97 million in the large woods.

It was thought desirable and worth while, in the course of this census, to collect the necessary data

* Forestry Commission. Census Report No. 2: Hedgerow and Park Timber and Woods under Five Acres, 1951. Pp. 88+12 plates. (London: H.M.S.O., 1953.) 5s. net.

for obtaining a rough estimate of the limited volumes of timber standing in the woodlands classified in the main census as simple coppice, scrub, devastated woods and felled woodland. In these types, there were often thinly scattered trees for which no estimate of volume was made at that time. One sample, usually one acre in extent, was measured on each type in each of the quarter-sheet maps used for the hedgerow estimates. The data indicate a total volume of 85·6 million cubic feet, fairly equally divided between the felled and devastated types taken together and the simple coppice taken with the scrub.

Summarizing the current growth data for all the timber of Great Britain, the combined census arrives at a figure of 115·5 million cubic feet annually on the growing stock of 3,773 million cubic feet, or 3 per cent. This amount is not, of course, available for immediate use, as apart from amenity considerations, much of it, particularly for the conifers, must be retained in the standing crops to grow to larger size. With the completion of this national inventory Britain moves into line with the still limited number of countries that have reliable statistics for their forest resources. It remains to keep the information up to date by a regular programme of field-work, since adjustment for estimated growth and reported fellings are inadequate for the purpose: this, it is believed, is being done by the Forestry Commission.

H. G. CHAMPION

CHARACTERISTICS OF THE IONOSPHERE IN GREAT BRITAIN

ONE of the major items in the programme of radio research conducted by the Department of Scientific and Industrial Research during the past twenty-five years has been the development and maintenance of ionospheric recording stations in Great Britain. Following the research work of Sir Edward Appleton and his co-workers at the Cavendish Laboratory, Cambridge, and the Radio Research Substation, near Peterborough, measurements were begun in 1929 at the Radio Research Station, Slough. In the following year a technique for measuring the critical frequency of the *E*-region was developed from experiments carried out between a transmitting station at the National Physical Laboratory, Teddington, and receiving stations at the Radio Research Station, Slough, and the Halley Stewart Laboratory, London. This enabled the present series of ionospheric measurements to begin in January 1931. As the experimental techniques developed and as knowledge of the complexity of the ionosphere increased, the scope and frequency of the measurements have expanded until, at the present time, observations are made every hour and recorded photographically.

An account of this development of the study of the characteristics of the ionosphere in Britain is described in Radio Research Special Report No. 23 of the Department of Scientific and Industrial Research*, which describes the general nature of the results obtained and illustrates the variation in the measured characteristics of the ionosphere during the period 1931–46.

For the past few years the results of such measurements have been compiled in tabular form and either circulated on an exchange basis to other organizations issuing similar information, or distributed to scientific workers and engineers who have a need for such knowledge in connexion with their research or with the various applications of radio transmission. There exists, however, a large quantity of observational material of great geophysical value accumulated in Britain which has hitherto not been available except in limited amounts and on specific request. The present publication is intended to remove this limitation, and to make available to all who are interested the accumulated results of the past work in this field. The complete data are comprised in nearly eight hundred tables of the results of observations made at the Radio Research Station, Slough, during the years 1930–46, and at Burghead, Scotland, during 1941–46. These tables, which are listed in appendixes to the report, reflect the gradual building up of the observational measurements as knowledge of the subject grew and as the experimental techniques available have developed to that of the present type of fully automatic equipment taking photographic records every hour.

Because of the expense, it is not possible to publish the tables in printed form, and arrangements have been made to make photo-copies available. These may be consulted at the Technical Information and Documents Unit of the Department of Scientific and Industrial Research, Cunard Building, 15 Regent Street, London, S.W.1, or by arrangement at the Radio Research Station, Ditton Park, Slough. Each table is on a separate sheet. A minimum of ten consecutive tables on microfilms can be supplied at 3*d*. per table and a microfilm copy of all tables costs £3 3*s*. Enlargements on sheets 9 in. by 7 in. are available at 1*s*. per table. Sets of not less than a hundred consecutive tables can be supplied at £2 10*s*. per hundred net. Requests for copies of the tables, which should quote table numbers, place of observation (that is, Slough or Burghead) and the form in which they are required (that is, microfilms or sheets) should be addressed to H.M. Stationery Office, P.O. Box 569, London, S.E.1.

The published report and the availability of the results in the above manner are likely to be of great value not only to those directly interested in the transmission of radio waves by means of the ionosphere, but also to those engaged in scientific research in related geophysical fields, such as solar phenomena, the upper atmosphere or the earth's magnetic field.

* Department of Scientific and Industrial Research, Special Report No. 23: Characteristics of the Ionosphere observed in Great Britain during 1930–1946. Pp. vi+16. (London: H.M.S.O., 1953.) 1*s*. 6*d*. net.

THE EXPRESSIONS 'GOLGI APPARATUS', 'GOLGI BODY' AND 'GOLGI SUBSTANCE'

By DR. JOHN R. BAKER
Department of Zoology, University Museum, Oxford

THERE are certain objects in cells, such as the nucleus, which obviously correspond from cell to cell and for which special names are necessary. The name 'Golgi apparatus' is commonly used with the implication that it refers to homologous bodies that exist in all or nearly all cells of animals. I myself formerly believed that nearly all cells of animals did, in fact, contain such homologous bodies, to which it was appropriate to give a single name.

The so-called Golgi apparatus or Golgi substance is ordinarily identified by its capacity to reduce osmium tetroxide or silver nitrate under certain specified conditions. Now, as I have argued at some length elsewhere[1], the so-called Golgi techniques are not reliable either morphologically or histochemically. They are very liable to give appearances that are misleading from the morphological point of view, because particles of osmium hydroxide or of silver tend to add themselves to one another without regard to pre-existing structure. When granules in the cytoplasm are grouped close together, osmium or silver tends to fill up the spaces between them. Thus a 'network' is produced in the epithelial cells of the mammalian epididymis, though when the so-called Golgi apparatus of these cells is separated by centrifuging it is seen to consist of separate, nearly spherical objects[2]. Similarly, it has recently been shown by Shafiq[3] that there are simple, spherical objects in the cytoplasm of the living nerve-cell of *Locusta* which are transformed by the classical Golgi techniques into the kind of 'Golgi bodies' known as 'platelets', with the characteristic circular or crescentic osmiophil rim.

The Golgi techniques have even less value in histochemistry than in morphology, for all sorts of chemically unrelated substances are capable of reducing osmium tetroxide and silver nitrate. Some of the objects called Golgi bodies are easily stained in life by the mitochondrial vital dyes, but not at all by neutral red or methylene blue; others are stained strongly by the two latter dyes, but not at all by the ones that stain mitochondria; others again cannot be stained by vital dyes of either type. Some take up sudan black in sections made on the freezing microtome, others do not; some can easily be shown by standard mitochondrial methods for paraffin sections, others cannot.

In recent years it has become possible to apply rigorous *in situ* histochemical methods to osmiophil bodies of various kinds[4], and a start has even been made towards their isolation for direct chemical and enzymological analysis[2,5]. May we not take encouragement from these developments, and view the whole subject in a new light? May we not content ourselves by describing how the lipide material is distributed in each particular cell—some of it perhaps as globules of reserve fat (simple triglycerides), some as a component of the mitochondria, and some *in various other forms*, differing widely in shape, composition and significance in different cases? May we not give accepted chemical names as soon as each constituent is identified, instead of using the expression 'Golgi substance', which has no meaning for the biochemist, the very person whose job it is to study the substances that compose the organism?

The massive evidence collected by Hirsch[6] has shown that secretory products of very various kinds arise in connexion with so-called Golgi bodies. Instead of saying that Golgi bodies secrete this or that, may we not say that newly formed secretion-globules often have a lipide-containing sheath around them, and then go on to give the chemical composition (and enzyme content, if any) of the sheath?

The names Golgi body, etc., are sometimes used with the secondary implication that these objects are always self-reproducing cellular constituents, so that all the bodies called by these names in any one animal are derived by division, like chromosomes, from those present in the fertilized egg. A review of the evidence for this opinion will show that it is very slender. It is true that lipide-containing globules of the kind often called 'dictyosomes' sometimes become constricted across, and Hirschler[7] has claimed to trace the continuity of the 'Golgi apparatus' through the cleavage-stages of the egg of *Limnæa*; but it would be extremely difficult to prove that all the various bodies called by the name of Golgi are self-reproducing. It seems more likely that many of them arise in the cytoplasm without connexion with any pre-existent similar object.

A particularly strong reason why the name of Golgi should not be used is that the Italian neurologist described his 'apparatus' in the nerve-cell of vertebrates, and this is, of all cells, the one in which the real nature of the object named after him is most uncertain. He described a network with *plaquettes* distributed on it, both the net and the rims of the *plaquettes* appearing dark by his silver technique[8]. The representatives in life of the *plaquettes* appear to be the colourless vacuoles or 'spheroids' that have been studied particularly by Thomas[9]. No agreement has been reached as to the precursor, in life, of the net. Perhaps it is formed largely by the impregnation of mitochondria with osmium hydroxide or silver. Perhaps it is largely an artefact. Adamstone and Taylor[10] have described "what appears to be an intricate reticulum" in the living cytoplasm of the spinal ganglion-cells of the rat. They say that the refractive index of the reticulum is so nearly the same as that of the surrounding cytoplasm that it is often very difficult to distinguish between the two. A careful study of their photomicrographs does not convince one of the existence of a network; but the object that they regard as reticular is seen to be bright by positive phase contrast, and therefore of somewhat lower refractive index than the ground cytoplasm. If in fact a *bright* network exists in the living cell, it must be something very different from the so-called Golgi apparatus or 'lepidosomes' of the spermatocytes of the snail, for example, for these are bodies of entirely different form and are without exception the *darkest* and most evident objects seen in the living cell when it is examined by positive phase-contrast microscopy. It would be very different also from the lipoidal droplets or granules (lipochondria) that so often represent in life what is called the 'Golgi apparatus' in an osmium or silver preparation.

From time to time the question is posed by colleagues and research pupils, about an object blackened by the classical Golgi techniques, "Is this a Golgi body?" I suggest that the proper answer would be, "I do not think that your question has a meaning. It is framed in terms of an improbable hypothesis".

It is, I hope, almost unnecessary to say that no disrespect is intended to the name of Golgi, whose contributions to neurology constitute his proper memorial.

[1] Baker, J. R., *Bull. Micro. App.*, **3**, 1 (1953).
[2] Schneider, W. C., Dalton, A. J., Kuff, E. L., and Felix, M., *Nature*, **171**, 161 (1953).
[3] Shafiq, S. A., *Quart. J. Micro. Sci.* (in the press).
[4] Baker, J. R., *Quart. J. Micro. Sci.*, **85**, 1 (1944). Cain, A. J., *Quart. J. Micro. Sci.*, **88**, 151 (1947). Gersch, I., *Arch. Path.*, **47**, 99 (1949). Arzac, J. P., and Flores, L. G., *Stain Tech.*, **27**, 9 (1952).
[5] Holtfreter, J., *J. Exp. Zool.*, **101**, 355 (1946); **102**, 51 (1946). Worley, L. G., *Exp. Cell. Res.*, **2**, 684 (1951).
[6] Hirsch, G. C., "Form- und Stoffwechsel der Golgi-Körper" (Borntraeger, Berlin, 1939).
[7] Hirschler, J., *Arch. Mikr. Anat.*, **91**, 140 (1918).
[8] Golgi, C., *Arch. Ital. Biol.*, **30**, 60 (1898).
[9] Thomas, O. L., *Quart. J. Micro. Sci.*, **89**, 333 (1948).
[10] Adamstone, F. B., and Taylor, A. B., *J. Morph.*, **92**, 513 (1953).

PORPHYRIN A AND OTHER PORPHYRINS FROM HEART MUSCLE

By Dr. R. LEMBERG, F.R.S.

Institute of Medical Research, The Royal North Shore Hospital, Sydney, Australia

THE problem of the chemical constitution of the prosthetic group of cytochrome oxidase and cytochrome *a* was neglected for many years until it was attacked again by Rawlinson, Hale, Rimington, Lemberg and Falk[1–6] in 1949. Recently publications, mostly of a preliminary nature, have appeared by Warburg and Gewitz[7], Granick[8], and Dannenberg and Kiese[9,10]. In this article, I propose to summarize work carried out by myself with the assistance of Miss J. Parker, Mr. W. H. Lockwood, Mr. P. Caiger and Mr. B. Bloomfield.

Whereas Warburg isolated hæmin *a*, which he calls cytohæmin, in crystalline form (in a way so far unpublished), we have chosen to isolate the porphyrin. This procedure has the advantage of facilitating separation of porphyrin *a* from protoporphyrin, derived from myoglobin and cytochrome *b*, and from other porphyrins, the presence of which the technique reveals. More important still is the sensitivity of the characteristic many-banded absorption curve of porphyrins in neutral organic solvent as criterion of homogeneity and stability. Crystallization is not a sufficient criterion of this in the porphyrin group, as has been shown, for example, by Lemberg and Parker[11], who used spectrophotometric control for a chromatographic separation of chlorocruoroporphyrin and diformyldeuteroporphyrin esters from an excellently crystallized mixture. Our procedure has the disadvantage of by-product formation during the removal of the iron. Small amounts of such artefacts were, indeed, encountered, but they can be readily detected and separated from porphyrin *a*. Moreover, they are also formed in stages of the preparation preceding the removal of iron, as the earlier conflicting results of Negelein and Roche and Bénévent show. In the hæmin, small amounts of by-products are difficult to detect, but they can be found after conversion to the porphyrins. We have, indeed, ascertained the presence of small amounts of hæmin *a* in well-crystallized protohæmin preparations from heart muscle by the isolation of porphyrin *a* which cannot arise from protohæmin.

Falk and Rimington[6] abandoned attempts to isolate porphyrin *a*, as they observed alteration by hydrochloric acid of the porphyrin shown by changes in the ratio of the four absorption bands (particularly III/IV and II/IV; for numbering of the bands see last lines of Table 1). Pure porphyrin *a* is, however, perfectly stable to 25 per cent (w/v) hydrochloric acid at room temperature, and by choosing a suitable method of isolation the substances which cause the alteration in the acid medium can be eliminated before the removal of iron and before hydrochloric acid fractionation of the porphyrins.

Preparation of porphyrin a. All the methods described so far have the following defects[15]: (1) The porphyrin *a* yields were variable and small, corresponding to 0·5–3 mgm. per kgm. of wet heart muscle. (2) The ratio of the absorption bands of the neutral porphyrin solution in organic solvents, particularly the III/IV ratio, varied (Table 1). (3) Porphyrin *a* was accompanied by variable amounts of cryptoporphyrins (see below) often exceeding that of porphyrin *a*. (4) The methods were complicated and did not lend themselves to estimation of the total porphyrin *a* derivable from heart muscle.

A practically quantitative isolation of porphyrin *a* from heart muscle in spectroscopically pure form can be achieved without previous separation of the cytochromes or hæmins and without chromatographic procedures. This consists of the following steps: (1) Extraction of the minced, washed, homogenized and centrifuged tissue by acetone–hydrochloric acid at 4° C. in a medium containing approximately 20 per cent (w/w, final concentration) of water. Previous drying of the tissue with acetone or alcohol must be avoided. (2) Freezing out at − 15° C. of fat and phospholipids from the filtrate, diluted with water to a concentration of 70 per cent (w/w) acetone. (3) Extraction of the hæmins from the filtrate by ether after dilution with aqueous hydrochloric acid, followed by removal of acetone and a troublesome emulsifying agent by careful washing with dilute hydrochloric acid containing a little ferrous sulphate. Small amounts of a white emulsion in the interface are separated by centrifugation. (4) Removal of the iron by a slightly modified ferrous acetate–hydrochloric acid procedure of Warburg and Negelein, in glacial acetic acid at 70–80° C. The whole process requires less than one minute; prolonged exposure to acetic acid, particularly at higher temperatures, must be avoided. (5) Removal of acetic acid and the emulsifying agent from the ethereal solution by washing with distilled water, centrifuging if necessary. (6) Extraction of protoporphyrin and other porphyrins by 3 per cent and 8 per cent (w/v) hydrochloric acid. (7) Extraction of porphyrin *a* by 20 per cent, 25 per cent and finally 28 per cent (w/v) hydrochloric acid. The extracts are intensely blue-green and have absorption bands at 619 and 565 mμ. The ether remains faintly yellow. The hydrochloric acid extracts can be used directly for quantitative estimation of porphyrin *a* ($E(0{\cdot}1\%, 1\text{ cm.}) = 13$ at 565 mμ). (8) Washing the hydrochloric acid extracts with ether and re-extraction of porphyrin *a* with ether after dilution with disodium hydrogen phosphate solution and neutralization with solid sodium bicarbonate. The 20 per cent and 25 per cent hydrochloric acid extracts contain 95 per cent of the porphyrin *a*, which is spectroscopically almost pure (cf. Table 1) with a III/IV ratio (2·03) far higher than that of any previous preparation. Further purification no longer alters this absorption spectrum

Table 1. Ratios of Absorption Bands I–III to Band IV

	I/IV	II/IV	III/IV	Solvent
Rawlinson and Hale	0·30	1·09	1·51	Pyridine
Lemberg and Falk	0·40	1·04	1·64	Dioxan
	0·275	1·31	1·78	Chloroform
Falk and Rimington	0·28–0·61	0·90–1·22	1·23–1·66	Pyridine
Dannenberg and Kiese	0·265	0·91	1·62	Ether
Kiese	0·223	1·04	1·75	Ether
Lemberg *et al.*				
Crude porphyrin	0·205	1·13	2·03	Ether
Pure porphyrin	0·185	1·16	2·03	Ether
	0·27	1·37	2·09	Acetone
	0·26	1·41	2·11	Chloroform

Band positions in ether: I, 648; II, 583; III, 558; IV, 517; V, 412 mμ; in chloroform: I, 646; II, 584·5; III, 563·5; IV, 520; V, 418·5 mμ

significantly. The small fraction obtained from the 28 per cent hydrochloric acid fraction has a somewhat lower III/IV ratio (about 1·80). The ether and acetone solutions of porphyrin *a* have a raspberry-red colour, showing red-green dichroism only at very high dilution.

Estimation. The yield measured by using an extinction coefficient $E(0{\cdot}1\%, 1\text{ cm.}) = 18$ for band III at 559 mμ in neutral ether solution is 16–18 mgm. per 1 kgm. of wet muscle tissue (0·21 kgm. dry weight). To this may have to be added 0·7 mgm. found as cryptoporphyrin *a* (see below). 200–500 gm. of tissue were usually used, but the analysis can be carried out with far smaller amounts. Sheep and pig heart gave similar, slightly smaller values.

It is interesting to compare these results with the values for concentrations of cytochromes $a + a_3$ which have been calculated by Ball[16] from spectrophotometric measurements on dispersed heart muscle preparations, or which may be calculated from similar measurements by Chance[17]. For this comparison it is assumed that porphyrin *a* is the iron-free prosthetic group of both cytochromes *a* and a_3, an assumption supported by our failure to discover any other porphyrin in significant concentration to account for either (see below). Ball finds a concentration of cytochrome oxidase (cytochrome a_3) of $4{\cdot}35 \times 10^{-6}$ gm. equivalents per kgm. of wet ox heart muscle, and a ratio of cytochrome *a* to cytochrome a_3 of 3 : 1, giving a concentration of $17{\cdot}2 \times 10^{-6}$ gm. equivalents/kgm. for total porphyrin *a*, which is in close agreement with our figures ($17{\cdot}1$–$19{\cdot}2 \times 10^{-6}$). From Chance's ratio for the concentrations $a_3 : a : c = 1 : 2 : 1{\cdot}6$ and the cytochrome *c* concentration in ox heart (about 15×10^{-6} gm. equivalents/kgm.), figures of $9{\cdot}2 \times 10^{-6}$ for cytochrome a_3 and $27{\cdot}6 \times 10^{-6}$ for total porphyrin *a* result. Both methods are indirect, and Chance's results require further assumptions on molar extinctions which are based on rather doubtful analogies. This may explain why they give higher values.

Reconversion of porphyrin a to hæmin a. The reconstituted hæmin *a* shows only one band (587 mμ) in the visible part of the spectrum, and a Soret band at 430 mμ after reduction of a slightly alkaline solution in 50 per cent pyridine with dithionite. We have not observed the appearance of a band at 558 mμ, which Warburg noticed on dithionite reduction. Since this readily occurs with cryptohæmin *p* (see below), Warburg's hæmin probably contained some of this hæmin as impurity. The ratio of the Soret band to the band at 587 mμ is remarkably low (4·5). This is also a feature of the ferrocytochrome *a* spectrum, though not of ferrocytochrome a_3. Altogether it appears that hæm *a* is far less modified in its properties by its combination with protein in cytochrome *a* than it is in the cytochrome oxidase.

Further purification. Further purification with removal of colourless impurities was carried out. (1) By extraction of fatty acids (together with a variable, usually small part of porphyrin *a*) from ether by 0·02 *M* phosphate of *p*H 6·5. Porphyrin *a* is extracted by disodium hydrogen phosphate and brought back into ether with phosphoric acid at *p*H 4. (2) By repetition of the extraction by hydrochloric acid from ether. The main part of porphyrin *a* is now extracted by 10 per cent and 15 per cent (w/v) hydrogen chloride and brought back into ether with neutralization to *p*H 4. The fact that the first fraction gives a porphyrin the ratio III/IV of which is not lower than that of the second proves the absence of cryptoporphyrins. (3) By repeated precipitation from chloroform by light petroleum or from ether by benzene. These procedures give fine precipitates which are distinctly microcrystalline under the polarization microscope. In a thin layer, solid porphyrin *a* is green in transmitted light; in a thicker layer it shows the typical metallic surface colour of porphyrins. (4) By fractional extraction of the solid porphyrin *a* with ether. This procedure is repeated until the first extracts have no lower specific extinctions than the later ones. Pure porphyrin *a* is not easily soluble in ether and the measurements are carried out in acetone.

Esterification with diazomethane causes no alteration of the absorption spectrum; but, so far, attempts to purify the ester further by chromatography or crystallization have failed.

By these methods the specific extinction coefficient ($E(0{\cdot}1\%, 1\text{ cm.})$) at 558 mμ in acetone was raised to between 16·0 and 18·1 in a large number of preparations. From the specific extinctions the molecular weight can be established if the molar extinction is known. Oliver and Rawlinson[12] have measured this by copper titration as 16,900 for band III of porphyrin *a* in acetic acid. Since the influence of solvents on the extinction of this band is negligible, we can calculate the molecular weight as 935. A second calculation giving a value of 930 is based on the sum of the specific extinction coefficients of bands III and IV ($18{\cdot}1 + 9{\cdot}5 = 27{\cdot}6$), and the sum of the molar extinction coefficients of these two bands, which is surprisingly constant for a great diversity of porphyrins, and for nineteen porphyrins of rhodo-type, averages 25,350 (cf. Table 2; values of A. Stern *et al.*[13], Lemberg and Parker[11] and Granick[14]).

Our molecular-weight value is higher than those which can be calculated for the porphyrin on the basis of iron estimations of the hæmin by Granick (850) and by Warburg (780). It confirms that porphyrin *a*, in contrast to other porphyrins, contains a large fatty acid or alkyl side-chain which does not contribute to its colour.

Structure of porphyrin a. Three characteristic side-chains have now been defined in porphyrin *a*: (1) a 'rhodofying' group which is practically certain to be a formyl group; (2) a second rhodofying group in a position strongly enhancing the effect of the formyl group on the spectrum, containing an ethylenic double bond; (3) a large alkyl or, more likely, fatty acid side-chain.

Evidence for the formyl group rests on reactions of the hæmin with cysteine[1], hydroxylamine[5] and hydrazine[5], on spectroscopic evidence for the conversion of an aldoxime to a nitrile[10], and on reaction of the porphyrin with aluminium propoxide[8] and with methanolic hydrochloric acid[8,15]. Porphyrin *a* does not contain the isocyclic ring which is present in chlorophyll derivatives. The alteration of the spectrum by methanolic hydrochloric acid superficially resembles the conversion of phæoporphyrins into chloroporphyrins; but is, in fact, a methyl acetal formation, since in contrast to the opening of the isocyclic ring it is readily reversed, for example, by the action of dilute hydrochloric acid on a chloroform solution of the acetal[15].

The ethylenic double-bond nature of the second rhodofying group is supported by the spectra of the compounds obtained by the action of diazoacetic ester or hydriodic acid, followed by hydroxylamine[3]

Table 2

Porphyrins	Rhodofying groups	Ratio III/IV	E_{mM}^{III+IV}
Phæo-a_7	C_8 to Cγ : —CO—O—C(OH)(CO_2M)—	1·18	23·2
6-Acetylpyrro-	—$COCH_3$	1·19	20·8
Oxochloro-e_4	2 : —$COCH_3$, 6 : —CO_2H (Cγ : CH_3)*	1·20	22·6
Acetyldeutero-	—$COCH_3$	1·27	24·5
Rhodo- XV	—CO_2H	1·29	27·0
Rhodo- XXI	—CO_2H	1·29	26·6
Chlorocruoro-	2 : —CHO (4 : $CH=CH_2$)*	1·40†	25·4
6-Acrylicpyrro-	—$CH=CH—CO_2$H	1·47	27·1
Chloro-e_5	C_8 to Cγ : —CO—O—CH(OH)—	1·50	24·5
Phylloerythrin	C_8 to Cγ : —CO—CH_3—	1·51	26·4
Pseudoverdo- D.E.A.-compound	6 : —CO_2H 2 : CH—CH_2 $CH—CO_2$E	1·55	28·0
Cyandeutero-	—CN	1·58	26·6
Formylpyrro-	—CHO	1·71	26·5
Formyldeutero-	—CHO	1·77†	—
Phæo-a_5	C_8 to Cγ : —CO—CH(CO_2M)—	1·71	25·4
Pseudoverdo-	2 : —CH=CH_2, 6 : —CO_2H	1·89	30·3
Oxophylloerythrin	2 : —$COCH_3$, C_8 to Cγ : —CO—CH_2—	2·14	23·8
Vinylphæo-a_5	2 : —CH=CH_2 C_8 to Cγ : —CO—CH(CO_2M)—	2·15	25·9
2,6-Bisacetylpyrro-	2 : —$COCH_3$, 6 : —$COCH_3$	2·36	19·4
Oxorhodo-	2 : —$COCH_3$, 6 : —CO_2H	2·39	27·7

* Negative rhodofying influence. † In chloroform ; in dioxan, 1·21 and 1·43.

and by observation on catalytic hydrogenation[7,8,10]. Lemberg and Falk[5] considered the rhodofying action of a vinyl side-chain insufficient to account for the porphyrin spectrum ; but recent observations of Granick[14] on vinylphæoporphyrin a_5 show that a vinyl group in a suitable position relative to a carbonyl group can have a very strong rhodofying effect (increase of the III/IV ratio from 1·71 to 2·15), although this still would not account for the very strong red shift of the porphyrin *a* absorption bands. Porphyrin *a* also behaves abnormally in reactions with hydrobromic acid in acetic acid, and with permanganate in acetone[15]. Table 2 shows that all porphyrins with a ratio of III/IV greater than 2 and a marked 'oxorhodo' type spectrum[5] (II/IV greater than 1), have two rhodofying groups on diametrically opposed pyrrole rings (in positions 2 and 6). The far lower ratio III/IV of chloroporphyrin e_4 is due to the presence of a methyl group on the methine bridge which lowers band III. Presence of two rhodofying groups on vicinal pyrrole rings, on the contrary, causes an ætiotype spectrum (ratio III/IV less than 1), independent of the relative positions of the groups on these pyrrole rings, for example, 2–4 in diformyldeuteroporphyrin, or 3–6 in phæoporphyrin *b*. Present evidence thus indicates the 2–6 position of the two rhodofying groups. Their presence on the same pyrrole ring, as assumed by Warburg, cannot be ruled out. It is conceivable that two such groups on one pyrrole ring may have the same effect as on opposite pyrrole rings, but there is no experimental evidence for this.

The long-chain lipophilic group of porphyrin *a* causing the large molecular weight is not present as an ester group ; no saponification occurs under conditions under which phytol is removed from chlorophyll[15]. This nature of porphyrin *a* explains the special difficulties of its preparation, and it must confer on cytochrome oxidase and cytochrome *a* a lipoprotein character. This is of particular interest because of the well-known close association of the respiratory cytochromes and lipids in mitochondria. Nature has achieved the conversion of a porphyrin to a lipid material in two different ways : by conversion into a fatty acid by C—C combination with a long fatty acid side-chain, probably by a semi-independent synthesis, for the respiratory enzymes of cytochrome *a* type ; and by esterification of a carboxyl with a large alcohol molecule for the chlorophylls.

Cryptoporphyrin. Porphyrin *a* is always accompanied by another porphyrin, the hæmin of which in pyridine-dithionite gives absorption bands at 582 and 533 mμ. This porphyrin was first obtained by Negelein[16] from pigeon breast muscle, but later considered as an artefact derived from protohæmin. Probably for this reason it has been neglected by later workers. It is found in the 8 per cent hydrochloric acid fraction of the Willstätter separation, and is best separated from accompanying protoporphyrin by 9 per cent (w/v) sulphuric acid. We have isolated cryptoporphyrin *a* from ox heart muscle from which the major part of the protohæm compounds, myoglobin, had been removed by saline extraction, and have obtained a crystalline methyl ester by esterification with diazomethane followed by alumina chromatography, by crystallization from ether at − 15° C., and by recrystallization from chloroform-ether. A similar porphyrin was obtained under certain conditions as crystalline methyl ester in a similar way from hæmoglobin and saline extracts of heart muscle, for example, when acetone was incompletely removed prior to treatment with ferrous acetate–hydrochloric acid. Table 3 shows that this porphyrin, which we call cryptoporphyrin *p*, differs from cryptoporphyrin *a*. Hydroxylamine shifts the absorption band of the cryptohæmochromogen *a* 20 mμ towards the blue, indicating that cryptoporphyrin *a*, like porphyrin *a*, is a formyl porphyrin, whereas the cryptoporphyrin *p* hæmochromogen behaves quite differently. The specific extinction coefficients of a solution of cryptoporphyrin *a* in chloroform are : $E(0{\cdot}1\%, 1\text{ cm.}) = 19{\cdot}45$ at 559 mμ and 15·7 at 519 mμ. From $E_{III+IV} = 35{\cdot}15$ a molecular weight of 700 (for the free porphyrin) is calculated. The yield of cryptoporphyrin *a* was established by spectrophotometric measurements in the crude mixture with protoporphyrin as about 0·7 mgm. per kgm. of wet heart muscle. Under

Table 3. CRYPTOPORPHYRINS

	Cryptoporphyrin *a*		Cryptoporphyrin *p*	
Absorption spectrum in chloroform	λ in mμ	Ratio to band IV	λ in mμ	Ratio to band IV
	642·5	0·21	636·5	0·215
	584	0·86	581	0·79
	559	1·32	554	1·14
	519	1·0	514·5	1·0
	421	13·3	415	13·8
Absorption spectrum in 10 per cent hydrochloric acid	λ in mμ 613, 563·5		608·5, 559·5	
Crystal form	Diamonds with 24° sharp angle		Almost rectangular elongated plates	
Melting point	259–260°		248–249°	
Hæmochrome + hydroxylamine	λ in mμ 582, 533 λ in mμ 562, 533		577, (556*), 525 610, 567	

* This band increases on standing with dithionite

conditions in which cryptoporphyrin *p* is not formed from protohæm, the yield is little altered by previous saline washings of heart muscle, indicating that cryptoporphyrin *a* is derived from hæm *a*, not from protohæm. Moreover, cryptoporphyrin *a* is obtained in the same yield from the ether fraction containing hæmin *a* from which protohæmin has been removed by washing with pyridine–hydrochloric acid according to Rawlinson and Hale. The molecular weight of cryptoporphyrin *a*, lower than that of porphyrin *a*, can be due either to the possible impurity of porphyrin *a*, or to cryptoporphyrin *a* having substantially higher molar extinctions for bands III and IV than porphyrin *a*. It will still have to be decided whether cryptoporphyrin *a* is an artefact derived from porphyrin *a* or is present as cryptohæm *a* in heart muscle; in any event it is present in too small a concentration to be the prosthetic group of either cytochrome oxidase or cytochrome *a*. This supports the assumption made above that porphyrin *a* is the prosthetic group of both cytochrome *a* and cytochrome oxidase.

This research has been supported by grants from the National Health and Medical Research Council of Australia. [May 29.

[1] Rawlinson, W. A., and Hale, J. H., *Biochem. J.*, **45**, 247 (1949).
[2] Rawlinson, W. A., Hale, J. H., Lemberg, R., and Falk, J. E., Abst. Comm., 1st Inter. Cong. Biochem., 378 (1949).
[3] Rimington, C., Hale, J. H., Rawlinson, W. A., Lemberg, R., and Falk, J. E., Abst. Comm., 1st Inter. Cong. Biochem., 379 (1949).
[4] Lemberg, R., Falk, J. E., Rawlinson, W. A., Hale, J. H., and Rimington, C., Abst. Comm., 1st Inter. Cong. Biochem., 351 (1949).
[5] Lemberg, R., and Falk, J. E., *Biochem. J.*, **49**, 674 (1951).
[6] Falk, J. E., and Rimington, C., *Biochem. J.*, **51**, 36 (1952).
[7] Warburg, O., and Gewitz, H.-S., *Hoppe Seylers Z. physiol. Chem.*, **288**, 1 (1951).
[8] Granick, S., *Fed. Proc.*, **11**, 221 (1952).
[9] Kiese, M., *Naturwiss.*, **39**, 403 (1952).
[10] Dannenberg, H., and Kiese, M., *Biochem. Z.*, **322**, 395 (1952).
[11] Lemberg, R., and Parker, J., *Aust. J. Exp. Biol. Med. Sci.*, **30**, 163 (1952).
[12] Oliver, T., and Rawlinson, W. A., *Biochem. J.*, **49**, 157 (1951).
[13] Stern, A., and Wenderlein, H., *Z. phys. Chem.*, A, **170**, 345 (1934); **174**, 83, 225 (1935); **175**, 406 (1935); **176**, 92 (1936). Stern, A., and Pruckner, F., *Z. phys. Chem.*, **180**, 322 (1937).
[14] Granick, S., *J. Biol. Chem.*, **183**, 713 (1950).
[15] Lemberg, R. (unpublished).
[16] Ball, E. G., Strittmatter, C. F., and Cooper, O., *J. Biol. Chem.*, **193**, 635 (1951). Ball, E. G., and Cooper, O., *J. Biol. Chem.*, **198**, 629 (1952).
[17] Chance, B., *Nature*, **169**, 215 (1952).
[18] Negelein, E., *Biochem. Z.*, **248**, 243 (1932).

MECHANISM OF PHAGE ACTION

By MARGERIS A. JESAITIS and WALTHER F. GOEBEL

Laboratories, Rockefeller Institute for Medical Research, New York 21, N.Y.

THE processes involved in the initiation of viral synthesis when phage and susceptible micro-organism encounter one another are by no means understood, despite the effort which has been expended these past few years to unravel this complex problem. The affinity between the bacteriophages and their hosts is highly specific and appears to be dependent upon the presence of receptor sites on the surface of both the virus particle and the bacterial cell alike. In the case of the dysentery bacillus Phase II *Sh. sonnei* and the various *T* coli-dysentery phages which attack this micro-organism, it has been suggested that it is the type-specific somatic antigen which serves as the viral receptor[1]. This suggestion has some basis in fact, for it has been shown that *in vitro* the chemically purified antigen derived from this bacillus has the ability to inactivate all of the *T* phages to which this micro-organism is susceptible[2]. The mode of action of this substance upon the virus is not known; it is our belief, however, that the antigen, as it occurs *in situ*, takes an important role in the initiation of the infectious process.

Recent studies on the interaction of isotopically labelled bacteriophage and *E. coli B* indicate that the virus particle is disintegrated when it comes in contact with the susceptible cell[3,4]. The purpose of the present investigation is to establish whether a similar event takes place when phage suffers inactivation *in vitro* by the somatic antigen of Phase II *Sh. sonnei*.

The wild type of the T_4 phage and the lipocarbohydrate moiety of the Phase II antigenic complex were chosen for study. A culture of *E. coli B* was grown in a synthetic medium and infected in the logarithmic phase with the T_4 phage. After lysis had occurred, the virus was concentrated by spinning in a Sharples centrifuge. It was purified by treatment with deoxyribonuclease; after filtration through a Berkefeld candle, the virus was finally obtained by differential centrifugation. Suspensions containing 10^{13} viral particles per ml. were thus secured. The bacterial lipocarbohydrate was prepared by dissociating in 90 per cent phenol the somatic antigen of Phase II *Sh. sonnei*, derived from formol-killed micro-organisms[5,6]. Sterile solutions of this material were prepared by wetting the lyophylized lipocarbohydrate with a small amount of 70 per cent ethanol (0·2 ml./10 mgm.) prior to dissolving it in sterile buffer.

If a solution of the specific bacterial lipocarbohydrate is now added to a dilute suspension of T_4 phage at 37° C. (10^{10} particles/ml. or less) no apparent changes can be detected apart from inactivation of the virus, as determined by infectivity titre. If, however, a highly concentrated phage suspension is mixed with the lipocarbohydrate, a marked and rapid

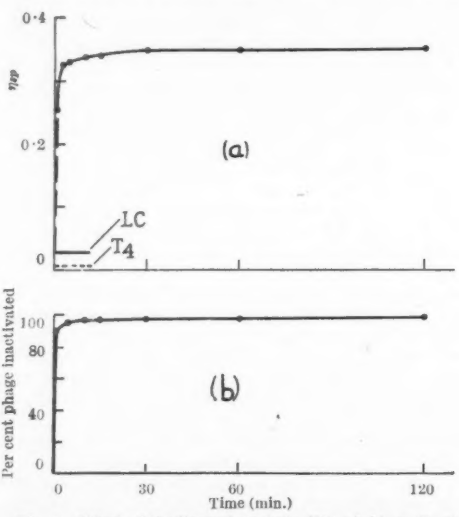


Fig. 1. Effect of the lipocarbohydrate (200 γ/ml.) on T_4 phage ($1{\cdot}85 \times 10^{11}$ particles/ml.) in 0·1 *M* sodium phosphate buffer at *p*H 6·8 and at 37° C. (*a*) Change in viscosity of T_4 suspension after addition of lipocarbohydrate; the specific viscosities of the lipocarbohydrate solution (*LC*) and of the phage (T_4) suspension alone are at the bottom of the diagram. (*b*) Rate of inactivation of the virus as measured by infectivity titration

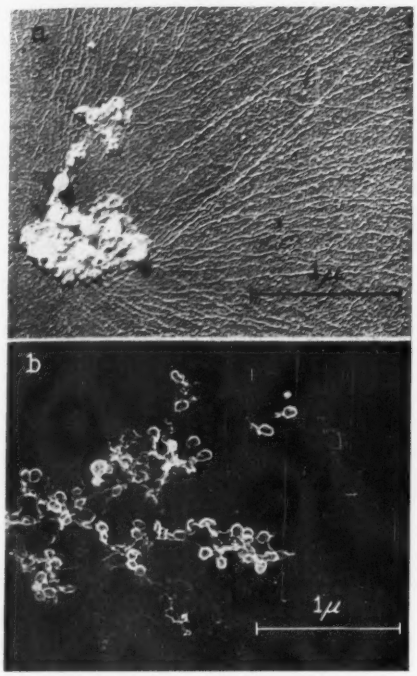


Fig. 2. Electron micrographs of T_4 phage after treatment with lipocarbohydrate. (*a*) Lysed virus with surrounding filaments; preparation obtained by drying a droplet of the solution on 'Formvar'-coated grid; shadowed with gold and chromium (× 24,000). (*b*) T_4 ghosts after lysis of the virus with lipocarbohydrate; preparation dehydrated by critical point method, shadowed with chromium (× 24,000). The micrographs were taken through the courtesy of Dr. Keith R. Porter, of the Rockefeller Institute

increase in the viscosity of the solution occurs. This change in viscosity is paralleled by inactivation of the phage (Fig. 1). Since the specific viscosity of the phage suspension and that of the lipocarbohydrate solution are low, it is evident that the marked increase in viscosity which occurs when the two substances are mixed can be attributed to the release of some new material in the solution.

Indeed, if one examines a desiccated droplet of the phage–lipocarbohydrate mixture in the electron microscope, it can be seen that the solution now contains a large number of phage ghosts and many filaments (Fig. 2*a*). Some scattered granular material can also be observed in the background of the electron micrograph. The clearly discernible filaments appear to be uniform in thickness and to extend over a distance of several microns; their diameter can be estimated as 50–100 A. A group of the lysed phage particles can be seen in the left corner of the electron micrograph; it will be noted that only a few intact phage particles remain. The structure of the empty phage membranes themselves can be more distinctly observed when the specimen for microscopy is prepared by the critical point method[7]. It is evident from the second micrograph (Fig. 2*b*) that the empty membranes retain for the most part the shape of the original phage particle; their tails, however, appear to be shorter than those of non-lysed phage. It will also be observed that here the filaments are coiled and twisted in a tri-dimensional pattern. Since the lipocarbohydrate itself appears on electron micrographs in the form of tiny granules 50–100 A. in diameter, it is very probable that the filaments originate from the phage particles themselves.

An investigation, not yet completed, is being made of the products which result from the interaction of the virus and the specific lipocarbohydrate. At the present time it may be stated that at least part of the phage nucleic acid is liberated in free form. It has been found that, on centrifuging the phage–lipocarbohydrate mixture, some 40 per cent of the total nucleic acid is carried down with the rapidly sedimenting protein components of the phage. The liberated nucleic acid not only sediments more slowly, but it also forms a separate and sharp boundary which has a sedimentation constant of $7{\cdot}0 \times 10^{-13}$. On electrophoresis this substance gave a single peak having a mobility of $-17{\cdot}4 \times 10^{-5}$ cm.^{2} volt^{-1} sec.$^{-1}$, calculated from the ascending pattern. The measurements were made in phosphate buffer at *p*H 6·8 and of ionic strength 0·1.

It can be observed, moreover, that on treating the lysed phage–lipocarbohydrate mixture with deoxyribonuclease the solution rapidly loses its viscosity. Apparently both the bound and free nucleic acid are hydrolysed by the enzyme, for a characteristic boundary can no longer be observed when the mixture is examined in the ultracentrifuge.

The lipocarbohydrate is apparently not destroyed when it reacts with the virus, since there is no liberation of dialysable saccharides. It has been found, on the other hand, that a given amount of lipocarbohydrate will inactivate only a certain number of phage particles; approximately 2×10^{-16} gm. of lipocarbohydrate is required to inactivate one viral particle. This fact indicates that the lipocarbohydrate is removed from the reaction mixture and in all probability is bound by the components of the lysed phage. Electrolytes are essential for the consummation of the reaction, for if the salt concentration is 0·02 *M* or less the phage remains unaffected. The reaction proceeds rapidly between *p*H 6·0 and 9·0, but not outside this range. Finally, it may be stated that, if the lipocarbohydrate is extracted with 70 per cent ethanol, it will no longer cause lysis of the phage. During this process a small amount of lipid is removed. This material in itself is without activity; but if it is again mixed with the extracted and inactive lipocarbohydrate the virolytic activity of the latter is fully restored. In this respect, the unidentified lipid can be considered as serving in the capacity of co-factor. Its action is not specific, however, as it has been found that certain saturated fatty acids such as myristic, palmitic and stearic acids will likewise fulfil this function.

In conclusion, it may be stated that, when the specific lipocarbohydrate of Phase II *Sh. sonnei* comes in contact with the coli-dysentery phage T_4, there is a prompt release of the content of the viral membrane. Since the lipocarbohydrate is a component of the antigenic complex which is present on the cell surface of the Phase II bacillus, it is our belief that it is this substance which triggers the release of genetically active material from the phage when the virus encounters the living host.

[1] Miller, E. M., and Goebel, W. F., *J. Exp. Med.*, **90**, 255 (1949).
[2] Jesaitis, M. A., and Goebel, W. F., *J. Exp. Med.*, **96**, 409 (1952).
[3] Lesley, S. M., French, R. C., and Graham, A. F., *Arch. Biochem.*, **28**, 149 (1950).
[4] Hershey, A. D., and Chase, M., *J. Gen. Physiol.*, **36**, 39 (1952).
[5] Morgan, W. T. J., and Partridge, S. M., *Biochem. J.*, **35**, 1140 (1941).
[6] Baker, E. E., Goebel, W. F., and Perlman, E., *J. Exp. Med.*, **89**, 325 (1949).
[7] Anderson, T. F., *Trans. New York Acad. Sci.*, **13**, 130 (1951).

LETTERS TO THE EDITORS

The Editors do not hold themselves responsible for opinions expressed by their correspondents. No notice is taken of anonymous communications

Growth of Excised Fern Leaves in Sterile Culture

The techniques of sterile culture have for some years been successfully applied to the elucidation of problems of the developmental physiology of roots and shoots[1], both of which possess meristems with indeterminate growth. More recently, the same techniques have been applied to a study of flowers and fruits[2], determinate organs which undergo only a limited meristematic development. Although detached leaves have been kept alive for varying periods of time[3], and leaf disks and small whole leaves have been reported to undergo limited growth in culture[4], so far as we are aware there has been no systematic attempt to use sterile culture techniques in the study of developmental problems of leaves. Because of its prolonged but limited terminal embryogeny, the fern leaf seemed to afford favourable material for such a study.

The fern used for these studies was *Osmunda cinnamonea* L., the cinnamon fern. This fern has a compact apical bud containing 60–80 immature leaves, one-quarter of which will be utilized in each of the four successive growing seasons[5]. Representative leaves from each of the inner three annual sets have been used in these experiments and have been designated for convenience sets I, II and III, I being the youngest. At the time of excision, set III leaves averaged 12·0 mm. in length, set II averaged 1·8 mm. in length, and set I less than 1 mm. in length.

The compactness of the bud facilitates sterilization since the inner leaves are already free of micro-organisms, and a surface sterilization of the whole bud in a 7 per cent solution of calcium hypochlorite does not injure these leaves. The excised leaves were grown for the most part on two media solidified with 0·8 per cent agar. The simpler of the two media contained Knop's solution with trace elements, 2 per cent sucrose, and a mixture of ten B vitamins. The more complex medium contained in addition to these constituents naphthalene–acetic acid (0·05 mgm./lit.), autoclaved coconut milk (15 per cent), and a mixture of eighteen amino-acids.

Excised leaves of diverse sizes and ages undergo growth and development in sterile culture, as indicated by increases of height, fresh weight and dry weight, and by the progressive appearance of new morphological features. The nature of the final product of leaf development *in vitro* is determined both by the size and age of the primordium at the time of excision and by the conditions of culture.

As an example of such development the growth of leaves of set III may be considered. At the time of excision these consisted of a broad basal portion at the tip of which was a tiny meristematic hook representing the initial stage of the crozier. Pinna formation was just beginning in the largest of the set III leaves. These leaves reached maturity in 8–10 weeks, undergoing, in one experiment, approximately a five-fold increase in height, a fourteen-fold increase in fresh weight, and an eight-fold increase in dry weight. At maturity the leaves possessed a rachis bearing about thirteen pairs of pinnatifid pinnæ. The appearance of new morphological features indicates that there had been organized meristematic growth in culture. This is in contrast to earlier reports of growth entirely by increase of cell size in cultured leaf disks[4].

Early increase in height of excised leaves was due to enlargement of the basal portion. Very soon, however, the crozier began to develop and eventually, at about the time that growth of the base was complete, it uncoiled, setting off successive pairs of pinnæ. This development of excised leaves closely resembles that of normal leaves on the plant with several notable differences. The height of the largest cultured leaves was approximately one-tenth that of typical fronds growing under natural conditions, and cultured leaves had only one-third to one half the number of pinnæ. Excised leaves of set III in culture reached maturity in 8–10 weeks, whereas comparable leaves on the plant would have required slightly more than a year, including a period of dormancy, to complete their development[5]. The extent to which the smaller size of cultured leaves may be related to their precocious development rather than directly to nutritional or other factors is not yet clear.

Excised leaves of set II and set I also underwent considerable development in culture, giving rise to fully mature fronds. It should be noted that the excised primordia of sets I and II gave rise to mature leaves which were smaller than those produced by set III explants (see accompanying table). However, the increase in size, relative to the original measurements, was many times greater in the younger leaves. The development of leaves of sets I and II was profoundly affected by the composition of the medium, not only in size but also in structure. On the more complex medium the mature leaves produced were both taller and heavier, and even the smallest primordia cultured produced tiny pinnate fronds. Leaves grown on the simpler medium, on the other hand, not only were smaller, but also showed a morphological reduction, being of a relatively simple type. In contrast to this, leaves of set III grown on the complex medium were somewhat heavier than those grown on the simpler medium, but showed no significant increase in height or in morphological development.

Growth of Excised Leaves of Sets I, II and III on Complex Medium

Set	Average initial: Height mm.	Fresh wt. mgm.	Dry wt. mgm.	Average final: Height mm.	Fresh wt. mgm.	Dry wt. mgm.	No. of pinna pairs
III	12·0	30·00	7·63	77·3	462·33	69·20	13·5
II	1·8	0·71	0·27	33·0	104·75	24·93	10·5
I	<1·0	—	0·08	11·0	22·66	6·52	5·3

Leaves of sets I, II and III were grown in the dark on both the simple and the complex medium. Older leaves developed more extensively, but in no case did any leaf reach maturity during the course of experiments in which all leaves in the light matured. Prior to uncoiling, however, the croziers of dark-grown leaves became considerably larger than those of leaves in the light, and contained a larger number of pinnæ. The uncoiling phase of development, however, was retarded, and in many cases did not occur at all.

The experiments reported in this communication have shown that it is possible to grow excised fern leaves in sterile culture from the primordial stage to maturity, under controlled nutritional conditions.

This technique makes possible a new approach to the problems of leaf physiology and development. At the same time it has been demonstrated that the complex pattern of leaf development in ferns, including apical growth of a determinate nature and the formation of lateral organs in regular sequence, is inherent in the leaf itself, although it may be modified by stimuli external to the leaf.

A detailed account of these experiments will be published elsewhere.

I. M. Sussex*
(Research Fellow in Biology)

Harvard University.

Taylor A. Steeves

Society of Fellows of
Harvard University.
Aug. 3.

* Under a grant from the American Cancer Society to Prof. R. H. Wetmore.

[1] White, P. R., *Plant Physiol.*, **9**, 585 (1934). Loo, S. W., *Amer. J. Bot.*, **32**, 13 (1945); **33**, 156, 295 (1946). Ball, E., *Amer. J. Bot.*, **33**, 301 (1946). Wetmore, R. H., and Morel, G., *Amer. J. Bot.*, **36**, 805 (1949). Wetmore, R. H., Rep. Proc. 7th Intern. Botan. Congr. Stockholm (in the press).

[2] Nitsch, J. P., *Amer. J. Bot.*, **38**, 566 (1952).

[3] Yarwood, C. E., *Bot. Rev.*, **12**, 1 (1946).

[4] Bonner, D. M., Haagen-Smit, A. J., and Went, F. W., *Bot. Gaz.*, 101, 128 (1939). de Ropp, R. S., *Ann. Bot.*, **11**, 439 (1947).

[5] Steeves, T. A., and Wetmore, R. H., *Phytomorph.* (In the press).

Action of Irradiated Cytoplasm on Untreated Chromosomes of the Silkworm

The possibility that irradiated cytoplasm may produce genetical effects in untreated chromosomes has been re-tested recently by Bonnier *et al.*[1], with inconclusive results, except for the case of gynandromorphs. The time interval between irradiation of the cytoplasm and entrance of the sperm would be expected to be a major factor in experiments of this nature. Recovery and photo-reactivation of irradiated cytoplasm have been observed by Henshaw[2] and Harold *et al.*[3] for the egg of the sea-urchin. This suggests that a possible mutagenic power of irradiated cytoplasm may also be lost if the interval between irradiation and fertilization is too long.

With this point in mind, I have tried to induce genetical effects in untreated silkworm spermatozoa which were introduced into irradiated eggs within two or four hours after irradiation. The mutant genes used were *pe* and *re*. Both are located on chromosome *V*, at 0·0 and 31·7 respectively. Both of them control the colour of the egg, or more accurately the colour of the serosa, which is a character of the F_1 generation. Whereas the normal colour is black, *pe*/*pe* eggs are white, and *re*/*re* eggs, red. Eggs homozygous for both mutants are also white.

Females of genotype *pe re*/*pe re* were irradiated with a dose of 80 kVp., 4 m.amp. at a target distance of 15·5 cm. and without filter. They were then mated to wild-type males. In order to shorten the interval between irradiation and egg-laying, the females were, previous to irradiation, kept at about 10° C. for 12 hr., and the period within which mating was possible was restricted to 2 or 4 hr. Control females were cooled in the same way. Eggs laid by control and treated females were classified as to colour. The normal colour of + +/*pe re* eggs is black. Red or white eggs, or eggs which are mosaic for black and red or black and white, are found very occasionally in the controls. They are frequent in the progeny of untreated *pe re*/*pe re* females and irradiated wild-type males[4]. Their occurrence in the progeny of untreated wild-type males and irradiated *pe re*/*pe re* females in excess of the control frequency would show an effect of the irradiated cytoplasm on the introduced paternal chromosomes. Since it is difficult to distinguish white eggs from unfertilized ones and red eggs from dead ones, classification for non-mosaic eggs was done at a later stage than for mosaic ones, and is less reliable. But as mosaics form the bulk of the aberrants, this does not materially affect the result.

The results from three experiments are summarized in the accompanying table. In spite of the unusually high frequency of aberrants in the second control test, the effect of the irradiated cytoplasm is clear in all the experiments. The magnitude of the difference between treated and control series depends on the X-ray dose (Exps. 1 and 2) and, to a greater extent, on the time interval between irradiation and fertilization (Exps. 1 and 3). The frequency of aberrants in Exp. 3, namely, 0·52 per cent, is comparable with the effect of 1,500 r. when applied directly to mature spermatozoa. With direct treatment of sperm also, the majority of the aberrants are mosaics[5].

The origin and production of mosaic eggs in the silkworm have been described by Tazima[5], who attributes mosaicism to the occurrence of deficiencies at the marked loci. This point will be further discussed in a forthcoming publication on the induction of mosaicism by nitrogen mustard. The fact that the ratio between white and red aberrants (50/29 = 1·72) is in good agreement with that found after direct treatment with nitrogen mustard is taken as support for the assumption that the observed effects

No. of exp.	Doses and intervals*	Total No.	Unfertilized and dead†	No. of eggs tested	White eggs (*pe*)	Red eggs (*re*)	White (*pe*) mosaics	Red (*re*) mosaics	Uncovering of 'pe' locus	Uncovering of 're' locus	Aberrant eggs No.	Aberrant eggs Per cent	Diff. / Stand. error
1	2,580 r. 4 hr.	9,831	492	9,339	1	1	7	7	8	8	16	0·172 ± 0·043	3·24
	Control	5,060	90	4,970	1	0	0	0	1	0	1	0·020 ± 0·020	
2	4,095 r. 4 hr.	6,201	297	5,904	1	2	14	4	15	6	21	0·356 ± 0·077	2·86
	Control	7,025	513	6,512	1	1	5	0	6	1	7	0·107 ± 0·040	
3	2,745 r. 2 hr. 30 min.	8,514	355	8,159	7	1	20	14	27	15	42	0·515 ± 0·079	6·05
	Control	5,060	90	4,970	1	0	0	0	1	0	1	0·020 ± 0·020	

* Time interval between irradiation and egg laying. † No. of eggs unfertilized or dead before pigmentation.
The controls of Exp. 1 are the same as those of Exp. 3.

are due to chromosomal deficiencies or other chromosomal aberrations.

Other possibilities which have to be considered are double fertilization, or abnormal fertilization between egg nucleus and a polar body nucleus. Indeed, cases of mosaicism due to one of these causes have been reported[6]. However, dispermic merogony cannot account for mosaics in the progeny of wild-type males, and areas arising from the fusion of two maternal egg nuclei would be genetically *pe re/pe re*, that is, white, so that at least the red mosaics cannot be due to this cause.

Somatic crossing-over should also be considered. In this case, the red areas would be due to double crossing-over, and this would mean an unusually high amount of double crossing-over.

Whatever the origin of the mosaics, it must be genetical in nature, and the present results thus show that irradiated cytoplasm may have a strong effect on untreated chromosomes.

I wish to thank Dr. C. Auerbach for her valuable criticisms and for her kindness in reading the original manuscript. Thanks are also due to Dr. Y. Tazima, of the Silk Science Research Institute, and Prof. K. Murati, of this Laboratory, for advice and assistance in completing this work.

Yoshio Nakao

Biophysical Laboratory,
St. Paul's University,
Tokyo. March 25.

[1] Bonnier, G., and Lüning, K. G., *Hereditas*, **37**, 469 (1951). Bonnier, G., *Brit. J. Rad.*, **25**, 180 (1952). Bonnier, G., Lüning, K. G., and Arnberg, B., *Hereditas*, **38**, 109 (1952).

[2] Henshaw, P. S., *Amer. J. Roent.*, **43**, 907 (1940).

[3] Harold, F. B., Robinson, J. C., and Loos, G. M., *Proc. U.S. Nat. Acad. Sci.*, **36**, 623 (1950).

[4] Tazima, Y., Rep. Co-ord. Research Genet., **2**, 153 (1951). Tazima, Y. (unpublished). Nakao, Y. (unpublished). Murati, K. (unpublished).

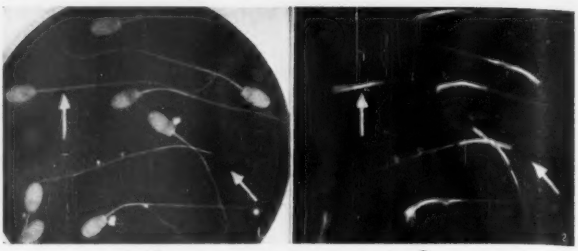
[5] Tazima, Y., "Mosaicisms in the Silkworm" (in Japanese, Tokyo, 1947).

[6] Hashimoto, H., Bull. Imp. Seric. Exp. Stat., **8**, 455 (1934). Tazima, Y., *Jap. J. Genet.*, **15**, 8 (1939); "Mosaicisms in the Silkworm".

Dark-Ground Illumination of Ram Spermatozoa

The tails of spermatozoa were generally thought to be radially symmetrical; although Randall and Friedlaender[1] have shown that the tails of ram spermatozoa are elliptical and slightly flattened, this may have been due to the drastic treatment necessary for inspection by electron microscopy. Challice[2], however, has produced more convincing evidence in the case of the mouse. He cut transverse sections of the spermatozoa tails, which, examined with an electron microscope, showed them to consist of a core of fibrils flanked by two ridges each composed of a single lateral fibril.

Departures of the tails and midpieces of spermatozoa from radial symmetry can be illustrated by using dark-ground illumination. The accompanying photographs are of the same preparation of ram spermatozoa treated with a nigrosin and eosin differential live/dead stain, one by dark-ground illumination and one by transmitted light. The midpieces of ram spermatozoa do not have the appearance one would expect if they were radially symmetrical. When viewed by dark-ground illumination, the lines of light representing the outline of the midpiece appear to cross, and when the same preparation is examined closely by transmitted light, the midpiece is seen to be slightly thinner at the cross-over point, an observation which may have been overlooked by previous workers.



A *B*

(*A*) Ram spermatozoa, treated with nigrosin and eosin stain, photographed by transmitted light. (*B*) The same preparation photographed by dark-ground illumination. In each photograph the arrow on the left points to one of the twisted mid-pieces, and the other arrow indicates the only stained spermatozoon in the field. (× 570)

There are several possible explanations of this; one of the most reasonable seems to be that the midpiece is elliptical in cross-section, and has become twisted. Randall and Friedlaender have confirmed their observations, on the main piece of the tail, by its appearance when twisted. Alternatively, the ram spermatozoa may have a similar structure to those of the mouse (as regards midpiece and tail) and the midpieces have become twisted. Challice, in Plate I, Fig. 1 of his paper[2], appears to have photographed a twist in the mouse spermatozoon tail. We have not been able to detect this by dark-ground illumination in mouse material, possibly because the tail is extremely fine. Twists have also been observed in spermatozoa of the boar, and once in those of the bull.

In the preparation illustrated, the twisted midpiece is found in spermatozoa which have not taken the stain, that is, in the live spermatozoa[3]. These can also be distinguished by dark-ground illumination because the outline of the head is clear, whereas the stained spermatozoon is ill-defined.

The twist has not been observed in spermatozoa untreated with nigrosin and eosin stain, and it may therefore be an artefact. This stain is, however, not particularly toxic to spermatozoa for they remain motile in it for some time, and distortion is slight, as can be seen by comparing a nigrosin and eosin preparation with cells viewed under the phase-contrast microscope.

If lateral ridges are a general morphological feature of spermatozoa, then it would be logical to expect a twist in the midpiece or tail to provide a mechanism for the rotary helical movement of the free spermatozoa.

I wish to thank Dr. A. Walton for advice and encouragement, and Mr. A. V. Guntrip for the introduction to dark-ground illumination and for taking the photographs.

H. M. Dott

Agricultural Research Council
Unit of Animal Reproduction,
Cambridge.
March 31.

[1] Randall, J. T., and Friedlaender, M. H. G., *Exp. Cell. Res.*, **1**, 1 (1950).

[2] Challice, C. E., *Proc. Soc. Study Fert.*, **4**, 21 (1952).

[3] Hancock, J. L., *Nature*, **167**, 323 (1951).

Carotene : a Rachitogenic Factor in Green-feeds

In a previous communication[1], evidence was presented indicating the presence of a rachitogenic factor in green-feeds. Experiments have shown that, for the rat on a rachitogenic ration, the bone ash response to a fixed dose of vitamin D is depressed by increasing doses of a green-feed extract in the manner indicated in Table 1.

Table 1

Group (18 rats per group)	Daily dose per rat: Vitamin D* (I.U.)	Daily dose per rat: Dried grass (mgm.)†	Average ash in dry fat-free femur (per cent)
1	0·075	0	33·2
2	0·15	0	37·9
3	0·15	1·75 (1·2 μgm. carotene)	38·1
4	0·15	3·5 (2·4 ,, ,,)	36·3
5	0·15	7·0 (4·8 ,, ,,)	35·6
6	0·15	14·0 (9·6 ,, ,,)	32·9
7	0·15	28·0 (19·2 ,, ,,)	31·6

* Amount dosed in 0·1 gm. olive oil solution.
† The equivalent weight of dried grass dosed as the chloroform extract in 0·1 gm. olive oil solution.

Statistical analyses carried out on these and on the results of eight other similar trials indicated a linear relationship between response (per cent bone ash) and log dose. A method was devised whereby an approximate estimate of the potency of the rachitogenic factor in a green-feed extract or concentrate could be obtained, an arbitrary unit being provisionally defined as "the amount which, when dosed daily to the rat on the McCollum 3143 rachitogenic ration plus a daily supplement of 0·15 I.U. vitamin D, would depress the bone ash response to that normally produced by a daily supplement of 0·10 I.U. vitamin D". Thus it became possible to follow quantitatively the fate of the active principle throughout the processes involved in its isolation. By chromatographic fractionation of a petroleum ether extract of dried green oats, the rachitogenic factor was isolated and identified as carotene.

The amount of carotene in each dose of extract described in Table 1 is indicated by the figures in brackets. The results obtained by dosing increasing amounts of carotene (B.D.H., 90 per cent β — 10 per cent α) to rats receiving the McCollum 3143 ration and a daily supplement of vitamin D are presented in Table 2.

Table 2

Group (24 rats per group)	Daily dose per rat: Vitamin D (I.U.)	Daily dose per rat: Carotene (μgm.)	Average ash in dry fat-free femur (per cent)
1	0·05	0	32·4
2	0·10	0	34·3
3	0·20	0	38·7
4	0·15	0·781	34·9
5	0·15	3·125	34·3
6	0·15	12·5	32·6
7	0·15	50·0	31·2
8	0·15	100·0	30·6

That vitamin A probably has a similar rachitogenic effect is seen from the results of a preliminary trial shown in Table 3.

Table 3

Group (12 rats per group)	Daily dose per rat: Vitamin D (I.U.)	Daily dose per rat: Vitamin A (I.U.)	Average ash in dry fat-free femur (per cent)
1	0·15	0	34·1
2	0·15	50	31·8

Analyses of green-feeds in this laboratory have indicated a carotene content as high as 840 μgm. per gm. of dry matter, so that animals grazing on such fodder have a high carotene intake—the equivalent of 1–2 million I.U. of vitamin A per day in the case of sheep, and for cattle about ten times this amount. In addition to this, an appreciable quantity of carotene appears to be synthesized by micro-organisms of the ileum and cæcum[2].

The identification of carotene as a rachitogenic factor for rats and the relatively large amounts of this substance present in green-feeds suggest that the rachitogenic effect of winter green-feed on sheep is due to the high carotene intake at a time of the year when the vitamin D status of the animal is normally low. This hypothesis is to be tested by sheep trials during the coming winter. The further possibility of a high carotene intake having other adverse effects on the health of farm animals is also being investigated.

A detailed account of this work, together with comprehensive statistical analyses carried out by Dr. A. H. Carter, of the Animal Research Station, Ruakura, will be presented elsewhere.

A. B. Grant
Wallaceville Animal Research Station,
Private Bag,
Wellington, New Zealand.
April 22.

[1] Grant, A. B., *Nature*, **168**, 789 (1951).
[2] McGillivray, W. A., *Brit. J. Nutrit.*, **5**, 223 (1951).

Tryptophane Metabolism in Rice Moth Larva (*Corcyra cephalonica* St.)

Earlier workers[1], who observed the excretion of the tryptophane metabolites, kynurenine and xanthurenic acid, by the rat and the rabbit under conditions suggestive of vitamin B deficiency, failed, however, to realize its physiological significance. It was not until Lepkovsky *et al.*[2] isolated and identified the pigment metabolite, xanthurenic acid, from the urine of pyridoxine-deficient rats receiving extra-dietary tryptophane, that the role of this vitamin in the metabolism of the amino-acid was unequivocally established. Since then, a number of reports have appeared of the conversion of tryptophane to xanthurenic acid, kynurenine, hydroxykynurenine, etc., by pyridoxine-deficient rats, rabbits and dogs[1,3]. In 1945, Sarma[4] found that the rice moth larva (*Corcyra cephalonica* St.), maintained on a pyridoxine-deficient diet containing added tryptophane, excreted yellow-coloured fæces. This was about the first and only report on the role of pyridoxine in tryptophane metabolism in insects and established a striking parallel in the metabolism of the amino-acid between mammals and insects. Pyridoxine had earlier been shown by the same author[5] to be an essential vitamin for the growth of the larva. The excretory pigment, however, was not characterized; but it was shown that it was not identical with xanthurenic acid, from the negative test it gave with iron salts. Tryptophane has also been shown to be the precursor of the pigments, ommochromes, found in the eyes and tissues of certain insects, and the production of the pigments appears to be controlled by genes[6]. Kynurenine and hydroxykynurenine, which are normal intermediates in this conversion, and kynurenic acid, which is derived from kynurenine by oxidative deamination

consequent on a gene mutation, have all been identified and isolated[1-9]. The present communication outlines further studies of the metabolism of tryptophane in the rice moth larva. The effect of the incorporation of DL-kynurenine and of D-tryptophane in the diet instead of DL-tryptophane and the chemical identity of the excretory pigment have been investigated.

The experimental technique was the same as that described by Sarma[5]. It was found that DL-tryptophane and DL-kynurenine, ingested at a level of 1 per cent in the larval diet, gave rise to yellow-coloured fæces, whereas D-tryptophane, at a level of 0·5 per cent, did not yield the same result, the colour of the excreta being white.

The role of the vitamin, pyridoxine, in tryptophane metabolism is well known[1]. In the reaction sequence, tryptophane → kynurenine → 3-hydroxykynurenine →3-hydroxyanthranilic acid→nicotinic acid, pyridoxine takes part in the conversion of 3-hydroxykynurenine to 3-hydroxyanthranilic acid, by acting as the prosthetic group of the enzyme, kynureninase, in the form of pyridoxal phosphate[3]. Thus a deficiency of the vitamin would lead to a block in the metabolic conversion of tryptophane at the stage of kynurenine or 3-hydroxykynurenine, both of which are coloured yellow and would be excreted as such or as conjugates. It is interesting, however, that unlike in the mammals the kynurenines are not further converted in the rice moth larva to xanthurenic acid. This was confirmed by the absence of the spot corresponding to this metabolite when the pigment was chromatographed on paper against an authentic sample of xanthurenic acid. The replacement of DL-tryptophane by DL-kynurenine for the same reason would be expected to yield essentially the same result, and, as already mentioned, this was actually found to be the case in feeding trials with the larvæ.

The metabolism of D-tryptophane in the larva was investigated with the view of comparing it with that in mammals. It is known that the rat, unlike the rabbit, can utilize the D-isomer of tryptophane as well as the L-isomer for growth and other metabolic purposes[1,10]. This is attributed to the action of the enzyme, D-amino-acid oxidase, in the tissues, which oxidatively deaminates the D-isomer to the keto-acid, which is then converted back to the amino-acid in the L-form. It has been found[11,12] that, in general, the highest concentrations of the enzyme are found in carnivorous, the lowest in herbivorous and intermediate in omnivorous organisms. On the basis of these results, therefore, the rice moth larva cannot be expected to be rich in the enzyme, and this is borne out also by the failure of D-tryptophane to be utilized, as reflected in the absence of pigment in the fæces. However, this was confirmed by the actual determination of D-amino-acid oxidase activity in larval tissues, using D-tryptophane as the substrate. The D-isomer was incubated with a pyrophosphate buffer[12] extract (*p*H 8·3) of normal larval tissue and the ammonia formed was determined by the Nessler reaction. It was observed that D-tryptophane did not yield ammonia over and above that liberated for the blank.

It is thus clear that D-tryptophane is not deaminated by the larval enzyme system, though unequivocal proof as to the complete absence of the enzyme, D-amino-acid oxidase, must await more detailed investigation with the isomers of proline and methionine, which are acted upon more readily than D-tryptophane[13]. Investigations in this direction are in progress.

The larval excretory pigment has been chromatographed on paper using two separate solvent mixtures, namely, butanol–acetic acid–water employed by Dalgliesh[3] and butanol–methanol–benzene–water adopted by Mason and Berg[14]. The former solvent system was found to give better resolution, but the results from the two series were interpreted cumulatively. One of the constituents of the pigment appears to be kynurenine or a derivative thereof, and another hydroxykynurenine, from their R_F values by chromatography against authentic samples of these substances, their fluorescence in ultra-violet light, colour reactions with Ehrlich's reagent and other specific chemical tests.

The excretory pigment has also been successfully chromatographed from an aqueous alcoholic solution on a column of acid-washed alumina, development being done with *M*/10 sodium phosphate. The interesting observation was made that both DL-tryptophane and DL-kynurenine in the larval diet yielded almost identical chromatographic patterns and fractions with similar ultra-violet characteristics.

These and related results will be published in detail elsewhere.

We would like to express our thanks to Dr. C. E. Dalgliesh and Dr. W. E. Knox for their generous gifts of DL-kynurenine and xanthurenic acid respectively.

T. K. Sundaram
P. S. Sarma

University Biochemical Laboratory,
Madras 25.
July 10.

[1] Dalgliesh, C. E., *Quart. Rev. Chem. Soc.*, **5**, 227 (1951).
[2] Lepkovsky, S., Roboz, E., and Haagen-Smit, A. J., *J. Biol. Chem.*, **149**, 195 (1943).
[3] Dalgliesh, C. E., *Biochem. J.*, **52**, 3 (1952).
[4] Sarma, P. S., *Proc. Soc. Exp. Biol. Med.*, **58**, 140 (1945).
[5] Sarma, P. S., *Ind. J. Med. Res.*, **31**, 165 (1943).
[6] Wigglesworth, V. B., "Ann. Rev. Biochem.", **18**, 595 (1949).
[7] Butenandt, A., Weidel, W., Weichert, R., and von Derjugin, W., *Z. physiol. Chem.*, **279**, 27 (1943).
[8] Butenandt, A., Weidel, W., and Schlossberger, H., *Z. Naturforsch.*, **4b**, 242 (1949).
[9] Hirata, Y., Nakanishi, K., and Kikkawa, H., *Science*, **112**, 307 (1950).
[10] Kallio, R. E., and Berg, C. P., *J. Biol. Chem.*, **181**, 333 (1949).
[11] Shanmugasundaram, E. R. B., and Sarma, P. S., *J. Sci. Indust. Res.*, **12B**, 245 (1953).
[12] Birkhofer, L., and Wetzel, R., *Z. physiol. Chem.*, **264**, 31 (1940).
[13] Krebs, H. A., "The Enzymes", edited by Sumner, J. B., and Myrback, K., **2**, Pt. 1, 499 (Academic Press, Inc., New York, 1951).
[14] Mason, M., and Berg, C. P., *J. Biol. Chem.*, **183**, 783 (1951).

Are *Torulæ* Haploid?

At irregular intervals, yeast geneticists have reported[1] the origin of asporogenous yeast types by the direct germination of spores. Naturally, they were entitled to believe that asporogenous yeasts generally referred to as *Torulæ* may have had a similar origin. Their suggestion that all asporogenous strains are 'haploid' could, however, be considered valid only if polyploidy did not occur in yeasts.

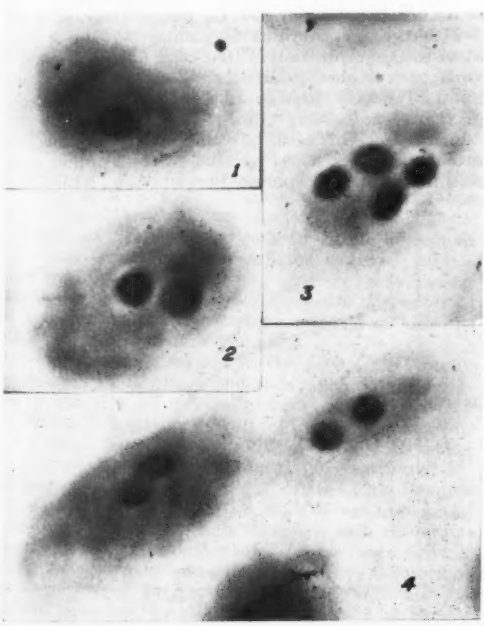
The demonstration of induction of tetraploidy in a brewery yeast in this laboratory[2] stimulated our interest in the problem. It was argued that if tetraploidy was common in yeasts, the spores of diploids should be different from those of polyploids in their chromosomal constitution', and hence the direct germination of a spore to give rise to an asporogenous type cannot be taken as critical evidence for haploidy.

The occurrence of spontaneous and induced tetraploidy in yeasts[4] rendered unreliable the highly variable morphological criteria employed by yeast geneticists for distinguishing 'haploids' from 'diploids' for the obvious reason that these do not enable a differentiation of the diploids from the polyploids[5].

Subramaniam[3] indicated the possibility that *Torulæ*, instead of being haploids, may really be sterile diploid hybrids. Support for this contention was offered by Windisch's[6] interesting observations on sporulation by a strain of *Torulopsis pulcherrima*. In higher plants it is known that a sterile diploid hybrid could give rise to a fertile allotetraploid. The present series of investigations on a strain of *Candida utilis* (Henneberg) Lodder and Kreger-Van Rij[7] (N.C.T.C. India, 3,010) was planned to elucidate its cytological behaviour.

A loop of yeast from a 12-hr. old culture was inoculated into a 50-ml. conical flask containing a thin layer of wort. After growth for 16 hr., the contents of the flask were shaken, most of them discarded and the remainder, mixed with 150 ml. of filtered wort, were transferred to a sterile aerator. Compressed air was bubbled through the medium using a sintered glass candle. After 6 hr., samples were removed at intervals of five minutes, centrifuged and smears prepared as usual[8]. The smears were fixed with osmic acid vapour and stained by the Feulgen technique[9].

At early prophase the nucleus contains a single chromatin mass (Fig. 1). The two chromosomes originating from the above are illustrated in Fig. 2 (cf. Thomas[10]). These reproduce, and at early anaphase four daughter chromosomes could be observed separating as two pairs (Fig. 3). One pair migrates to the bud. In Fig. 4, the two chromosomes in the mother cell are synapsing while those in the bud still remain discrete.



Longest diameter of cell: (1) 3·6 μ; (2) 3·6 μ; (3) 3·6 μ; (4) 7·2 μ (mother cell with bud)

Attention is invited to the remarkable similarity between the mitotic behaviour of *Candida utilis* and that reported earlier for the sporogenous two-chromosome brewery yeast[11], *BY* 1. The minimum number of chromosomes necessary for normal meiosis is only two, and hence the inability of our strain of *Candida* to sporulate must be due to other factors. It is quite likely that it may be a diploid hybrid in which the chromosomes are unable to pair as a necessary precedent to normal meiosis. If that is so, a doubling of the chromosome number in this strain should make it a sporogenous one (cf. ref. 6). The possession of a basic chromosome complement essential for sporulation indicates that the strain of *Candida utilis* studied cannot be considered a haploid.

Diploid yeasts have been reported to be asporogenous[1,12]. The mere fact that a strain has originated by the direct germination of a spore, or that it is incapable of sporulation, does not entitle one to conclude that it is a haploid. Are we then justified in believing that the various strains of *Torulæ* could have originated by the direct germination of haploid spores with concurrent loss of ability to become diploids?

M. K. Subramaniam
B. Ranganathan

Cytogenetics Laboratory,
Department of Biochemistry,
Indian Institute of Science,
Bangalore 3.
March 26.

[1] Winge, Ö., and Laustsen, O., *C.R. Lab. Carlsberg, Ser. Physiol.*, **22**, 99 (1937). Lindegren, C. C., and Lindegren, G., *Ann. Mo. Bot. Garden*, **31**, 203 (1944).
[2] Subramaniam, M. K., *Curr. Sci.*, **14**, 234 (1945); *Proc. Nat. Inst. Sci. India*, **13**, 129 (1947); *Cellule*, **54**, 145 (1951*a*). Subramaniam, M. K., and Ranganathan, B., *Proc. Nat. Inst. Sci. India*, **14**, 279 (1948). Ranganathan, B., *J. Ind. Inst. Sci.*, **32** A, 91 (1950).
[3] Duraiswami, S., and Subramaniam, M. K., *Cellule*, **53**, 215 (1950). Subramaniam, M. K., *J. Ind. Inst. Sci.*, **32** A, 29 (1950).
[4] Ranganathan, B., and Subramaniam, M. K., *Proc. Nat. Inst. Sci. India*, **14**, 389 (1948). Royan, S., and Subramaniam, M. K., *Nature*, **169**, 932 (1952).
[5] Subramaniam, M. K., *Curr. Sci.*, **20**, 257 (1951*b*).
[6] Windisch, S., *Arch. Mikrobiol.*, **9**, 551 (1938).
[7] Lodder, J., and Kreger-Van Rij, N. J. W., "The Yeasts: a Taxonomic Study" (1952).
[8] Subramaniam, M. K., *Proc. Nat. Inst. Sci. India*, **14**, 315 (1948).
[9] Subramaniam, M. K., and Raganathan, B., *Nature*, **157**, 657 (1946).
[10] Thomas, P. T., *Nature*, **156**, 738 (1945).
[11] Subramaniam, M. K., *Proc. Nat. Inst. Sci. India*, **12**, 143 (1946). Duraiswami, S., and Subramaniam, M. K., *Experientia*, **7**, 422 (1951).
[12] Lindegren, C. C., and Lindegren, G. *J. Gen. Microbiol.*, **5**, 885 (1951).

Prochromosomes and Supernumerary Chromosomes in *Rhinanthus minor* Ehrh.

The resting nucleus of *Rhinanthus minor* Ehrh. is characterized by the presence of a variable number of irregular bodies which stain with Feulgen's stain. These bodies were described as occurring in the genus *Alectorolopus* (= *Rhinanthus*) by Witsch[1], who regarded them as fused chromocentres. There are usually four to eight of the bodies in the resting nucleus although the number varies between one and fourteen. They are visible under certain conditions in the living cell and cannot therefore be regarded as artefacts due to fixation. There is usually one nucleolus (rarely two) in the resting nucleus. Each nucleolus is closely appressed at one or more points to one or more of the stainable bodies. The connexion is such that, where a single nucleolus is present, it is sometimes pulled into a spindle shape,

Fig. 1. Resting nucleus of *R. minor* showing three prochromosomes lying against the nuclear membrane. The single nucleolus is attached to two of the prochromosomes by apparently double attachments. (× 1,200)

Fig. 2. Anaphase of *R. minor* in which four small *V*-shaped supernumerary chromatids may be seen in one of the anaphase plates. (× 2,400)

more rarely a triangle or rectangle, the two, three or four points of contact with the stained bodies representing the respective apices of these figures.

At mitotic prophase the nucleoli disappear and each of the stained bodies gives rise directly to one or more chromosomes, which as they become distinct can be seen to possess the relic coils of the previous metaphase. The prophase chromosome has a long unstained distal region, the centromere being in most cases sub-terminal. It would seem from the foregoing evidence that the major part of the prophase chromosome (the stained region) arises directly from one of the stainable bodies in the resting nucleus, each of which may contain one or more chromosomes. At metaphase satellites have been observed attached to two of the complement. Distortion of the nucleolus is consistent with the view that the satellite may be contained in one body and the remainder of the chromosome in another; these would be connected by a thin unstained nucleolar organizing region passing through the nucleolus. Alternatively, it is possible that there are four nucleolar organizing regions in the complement.

In view of the evidence that the chromatic bodies contain part of, if not all, the chromosome, the term 'prochromosome' might be more suitable than the term 'chromocentre', which is usually applied to bodies which occur in constant number in the resting nucleus and which represent heterochromatic regions of chromosomes.

In late prophase and metaphase a number of supernumerary chromosomes become stainable. At metaphase these are seen to be double, and at anaphase pass to the poles perfectly regularly. At least four of these possess a median centromere (visible at metaphase) which gives rise to a *V* configuration at anaphase (Fig. 2). These supernumerary chromosomes occur in root and shoot and have not yet been observed to be lost at anaphase. They are much smaller than the 'normal' complement and stain feebly, and can therefore be counted only with some difficulty. The maximum number of these small chromosomes yet found is eight.

The diploid number for *Rhinanthus minor* Ehrh. is 14. In addition to this constant count there is a number, possibly variable, of supernumerary chromosomes.

David J. Hambler

Queen Mary College
(University of London),
Mile End Road,
London, E.1.
May 4.

[1] Witsch, H., *Österr. Bot. Z.*, **81**, 108 (1932).

Origin of Reverse Thermo-remanent Magnetism of Igneous Rocks

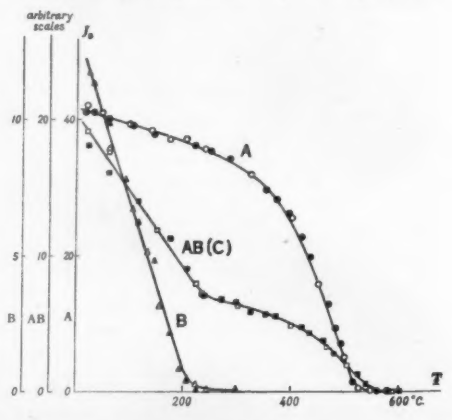
In a previous article[1], one of us (T. N.) reported the phenomenon of self-reversal of the thermo-remanent magnetization of the ejecta of Mt. Haruna and of the ferromagnetic minerals separated from the rocks. It was also proved experimentally that the characteristics of the reverse thermo-remanent magnetization of the ferromagnetic minerals are the same as those of reverse thermo-remanent magnetism of their mother rocks.

For the physical mechanism of the production of reverse thermo-remanent magnetism, Néel[2] proposed a possible process in which the ferromagnetic minerals are composed of two different constituents of widely different Curie point; the magnetization of the constituent of lower Curie point is affected by the demagnetizing field arising from the magnetization of the constituent of higher Curie point. The characteristics of the reverse thermo-remanent magnetism of the Haruna rocks obtained so far seem to agree fairly well with this assumption[3].

In order to examine this assumption more directly, the ferromagnetic minerals of the Haruna rocks have been investigated. Ferromagnetic material, of mean diameter 0·3 mm., was separated magnetically at high temperatures in nitrogen gas. The result showed that the grains can be divided into three groups: namely, *A*-grains, which are strongly magnetic at temperatures higher than 300° C.; *B*-grains, which are non-magnetic at temperatures higher than 300° C. but are magnetic below 200° C.; and *C*-grains, which have weak magnetic properties at temperatures higher than 300° C.

The change of saturation magnetization (J_s) with temperature (T) of these three kinds of grains was measured. The accompanying graph illustrates the change of J_s with temperature of each class of grain, *A*, *B* and *C*. The Curie points of the *A*- and *B*-grains are almost 530° C. and 230° C., respectively, and the J–T curve for *C*-grains is similar to the resultant of the superposition of that of *A* and *B*. In other words, each single *C*-grain consists of two constituents, *A* and *B*, so that the *C*-grain will be denoted by *AB*.

Experiment shows that the thermo-remanent magnetization of both *A*- and *B*-grains has the normal direction, being parallel to the applied magnetic field, at atmospheric temperature, while that



Curve *A*, ●, heating process; ○, cooling process. *AB*(*C*), ■, heating process; □, cooling process. *B*, ▲, heating process; △, cooling process

of the AB-grains in the same condition is the reverse. This self-reversal of thermo-remanent magnetization takes place even in a single AB-grain. It may be concluded, therefore, that the magnetic interaction between the A- and B-constituents within each AB-grain is responsible for the reverse thermo-remanent magnetism of the whole group of ferromagnetic minerals as well as for that of their mother rocks. It may well be that the thermo-remanent magnetization of the B-constituent within an AB-grain is developed under the effect of a demagnetizing field caused by the neighbouring A-constituent within the grain, so that the magnetization of the B-constituent is opposite to the applied magnetic field. The reverse remanent magnetization of the B-constituent becomes larger than the normal magnetization of the A-constituent at atmospheric temperature. The plausibility of the latter argument may be verified by comparing the steep temperature gradient of J_s in the case of the B-constituent with the small gradient of the A-constituent, shown in the graph.

So far as the reverse thermo-remanent magnetism of the Haruna rocks is concerned, the general principle of Néel's theory appears applicable; but it seems to need a slight modification since the magnetic interaction between the two constituents within each grain only is effective, the interaction between the separate grains of different kinds being not primarily significant. It has been proved, in addition, that the A-constituent is nearly stochiometric magnetite, while the B-constituent is rich in titanium oxide (TiO_2). The detailed chemical and crystallographic examination of each mineral constituent is now proceeding.

With reference to the basaltic rock mass at Genbudo, Japan (Tertiary lava), which according to Matuyama[4] has remanent magnetization almost opposite to the present geomagnetic field, this rock shows no positive evidence of reverse thermo-remanent magnetism such as is found in the Haruna rock.

Note added, April 9. A study of the article entitled "Magnetic Properties of Rocks" in *Nature* of March 21 suggests the following comments.

We have examined the magnetic properties of a Whin Sill sample, which was sent us by courtesy of H. Manley. The result shows that the direction of its thermo-remanent magnetism is perfectly parallel to the magnetic field, and its other magnetic properties are completely normal. Among a number of other Japanese samples examined so far, only the dacitic pitchstone of Ashio showed reverse thermo-remanent magnetism similar to that of the Haruna dacite. Hence we do not claim that all igneous rocks having adverse magnetization *in situ* have the character of the adverse thermo-remanent magnetism due to Néel's two-component mechanism.

We are much interested in the report that many experiments in England and in France on the magnetic properties of naturally adversely magnetized rocks gave a negative result for Néel's mechanism. At the same time, we cannot ignore the interesting fact of the adversely magnetized gneisses found by Buddington. The magnetic properties of his samples must also be studied in detail, and we are now going to do this. Thus, although we agree with the argument that a large number of igneous rocks having natural adverse magnetization *in situ* have the normal characteristics of thermo-remanent magnetism in its ordinary meaning, we still hesitate to conclude finally that the earth's magnetic field was reversed during certain geological times, because, from our recent studies, the magnetic properties of igneous rocks seem to be much more complex than their other properties. For example, the ferromagnetic minerals even in a small piece of rock show a wide range of Curie point, and the presence of magnetic interaction between closely neighbouring ferromagnetic constituents is rather usual, though it is in many cases not strong enough to result in reverse thermo-remanent magnetism.

Until, therefore, the physics of the magnetic properties of rock-forming ferromagnetic minerals are well established, the possibility should not be rejected that there exists an unknown mechanism for producing adverse remanent magnetization. The reversal of the magnetic field of the earth during its history must not be assumed without further evidence.

We thank Prof. Néel for discussion.

T. Nagata
S. Akimoto
S. Uyeda

Geophysical Institute,
Tokyo University.
Feb. 18.

[1] Nagata, T., *Nature*, **169**, 704 (1952).
[2] Néel, L., *Ann. Géophys.*, **7**, 90 (1951).
[3] Nagata, T., Uyeda, S., and Akimoto, S., *J. Geomag. Geoelect.*, **4**, 22 (1952). Néel, L., *C.R. Acad. Sci., Paris*, **234**, 1991 (1952).
[4] Matuyama, M., *Proc. Imp. Acad. Japan*, **5**, 203 (1929).

Radiocarbon Dating: Large-scale Preparation of Acetylene from Organic Material

The introduction of the radiocarbon method of dating materials of organic origin by Libby, Anderson and Arnold in 1949 [1] provided the archæologist with an important new tool, and the number of inquiries received by the British Museum laboratory immediately after the announcement indicated the need for carbon-14 dating facilities in Great Britain. As the British Museum laboratory seemed to be the appropriate body to administer such a service, an approach was made in July of that year (1949) to the Atomic Energy Research Establishment, Harwell, for help and advice in setting up such a service.

After investigating the whole problem, the Atomic Energy Research Establishment advised an alternative approach to that of Libby, Anderson and Arnold, namely, conversion of the carbon in the sample to a gas (preferably a diatomic one such as acetylene or ethylene) and subsequent counting of the carbon-14 activity in a proportional counter. While this course of action might result in a long delay before a dating service was available, owing to the amount of research and development necessary, it could possibly lead to two important improvements from the archæological point of view, namely, reduction of sample requirements and increased accuracy of the calculated dates.

Work on the problems of quantity production of acetylene was begun at Harwell in October 1950, and transferred to the British Museum laboratory a few months later, where a plant was built so that the chemical problems could be studied in parallel with those of counter design at Harwell.

Later, in 1951, as a result of an independent approach to the Atomic Energy Research Establishment by the Royal Institution, more resources became available for counter design, and since May 1952

there has been close collaboration between the Royal Institution and British Museum laboratories, it being agreed that the problems of acetylene production and the associated analytical control problem of acetylene and lithium purity should continue to be examined at the British Museum.

The method of acetylene production is based on that of Arrol and Glascock[2] for the conversion of carbon dioxide to acetylene on a microscale, but using lithium instead of barium. The sample is burned in a stream of oxygen at atmospheric pressure in a silica furnace of special design—there being difficulties with the traditional copper oxide packing when burning material which yields large quantities of volatile products. The resulting carbon dioxide is freed from water vapour and other condensible impurities by passing through traps cooled to − 78° C. and is condensed in further traps at liquid-oxygen temperature. When the combustion is finished, non-condensable gases are pumped away and the carbon dioxide is expanded into storage bulbs until required. The carbon dioxide is then allowed to react with an excess of metallic lithium at high temperature (700° C.) in a stainless-steel furnace of the type described by Arrol and Glascock[2], to give lithium carbide. Acetylene is then obtained from the carbide by the addition of carbon dioxide - free, distilled water.

Good yields of carbide are favoured by using a large excess of lithium and allowing the reaction (which is exothermic) to proceed at as high a temperature as possible. Good yields of acetylene are only obtained in practice if the final concentration of lithium hydroxide in the furnace after the addition of water is not much in excess of 5 per cent, since the rate of evolution of acetylene from lithium carbide falls off markedly as the concentration of lithium hydroxide rises. In practice, it has been possible to obtain approximately 65 per cent efficiency for the conversion $CO_2 \rightarrow C_2H_2$ by employing a 50 per cent excess of lithium and a furnace of such dimensions that the final concentration of lithium hydroxide was not greater than 10 per cent. This should be improved upon when a large furnace becomes available.

After liberation from the carbide, the acetylene is freed from condensable impurities by passage through a trap at − 78° C. and is condensed at liquid oxygen temperature, while hydrogen liberated at the same time by reaction of the excess lithium with the water is pumped away. The acetylene is finally purified by repeated passage over solid adsorbents.

It is hoped in the New Year to complete the installation of carbon-14 dating apparatus incorporating these processes and the counting techniques developed by the Atomic Energy Research Establishment, Harwell, and the Royal Institution, thus providing at the British Museum laboratory a complete dating system which will be used in the service of archæology.

I wish to thank the Director of the Atomic Energy Research Establishment, Harwell, for the generous provision of facilities, and Dr. W. J. Arrol, Isotope Division of the Establishment, for his help and encouragement in the early stages of the work.

H. Barker

Research Laboratory,
British Museum,
London, W.C.1.

[1] *Science*, **109** (No. 2827), 227 (1949).
[2] Arrol and Glascock, *Nature*, **159**, 810 (1947).

Use of an Acetylene-filled Counter for Natural Radiocarbon

The use of natural carbon-14 activity for purposes of archæological dating was suggested by Libby, who used a screen-wall counter[1]. The majority of workers in this field have employed the same type of counter in which the carbon is introduced as a solid. However, the counting of carbon-14 in its elementary form appears to be inherently a method of low efficiency, and the alternative use of a counter in which the filling gas is also the sample seems to offer greater scope for improvement. This has been the subject of several recent publications. De Vries and Barendsen[2] have used carbon dioxide as the sample gas, and Faltings[3] has considered the use of methane as an alternative to carbon dioxide. A further improvement may be sought by the use of a gas containing more than one carbon atom per molecule, and to this end an apparatus has been constructed in this laboratory for the counting of natural radiocarbon in the form of acetylene.

The operating conditions for a counter which will produce the best statistical accuracy for a sample rate of counting S, where the background rate B is random, is given by the largest obtainable value for S^2/B. In general, this ratio will increase with increasing size of counter and will increase more rapidly with size for a gas-sample counter at constant pressure than for a solid-sample counter. This follows from the fact that the ratio S/B also increases for the former counter but remains approximately constant for the latter. This is shown in an analysis by Anderson and Levi[4]. On these grounds the gas counter should be as large as possible ; but in practice limits are set by the difficulties of shielding and by the desirability of not too high an operating voltage.

In the work outlined here a mild steel counter of about three litres volume is employed and thus 3 gm. of carbon may be introduced by filling to one atmosphere pressure with acetylene. The counter is surrounded by eleven Geiger counters used in anti-coincidence and the whole array is enclosed in a 4-in. thick lead shield. The sample counter is operated in the proportional region and a further reduction in background is thus obtained by discriminating against small pulses ; in this way some of the smallest β-particle pulses from the decay of carbon-14 are also lost and the optimum discriminator setting is determined by plotting bias curves for background and sample-plus-background counts. The background counting-rate is obtained by filling the counter with acetylene produced from anthracite, which contains no carbon-14. Under standard operating conditions, this value for the background is 30 c.p.m. A figure for the efficiency of the counter for detection of carbon-14 may be obtained by filling it with acetylene made from modern biological material such as contemporary wood. For such material Libby has found the specific activity to be 15·3 disintegrations per min. per gm. Maintaining the same operating conditions as for the background determinations and filling the counter with acetylene made from contemporary wood, the count-rate is 64·5 c.p.m. This corresponds to an efficiency for carbon-14 of 75 per cent at the optimum discriminator setting : minimum discriminator setting gave a counting efficiency of 90 per cent but poorer sample statistics. The figure quoted by other workers using screen-wall counters is about 5 per cent.

The acetylene is prepared in this laboratory from organic material as described by Dr. H. Barker (p. 632). Further improvements over the figures so far obtained may be sought by improvements in shielding and by the use of acetylene at pressures in excess of atmospheric. A full description of the apparatus and method will appear elsewhere.

My thanks are due to Prof. F. E. Zeuner, of the Institute of Archæology, London, for his part in the initiation of this work and for his continued interest. Preliminary studies of gas production and counter design were made at the Atomic Energy Research Establishment, Harwell, and I wish to thank the Director for the generous provision of facilities, and members of the Isotope and Electronics Divisions for their assistance.

A. R. CRATHORN

Davy-Faraday Research Laboratory,
Royal Institution, Albemarle St., London, W.1.

[1] Libby, W. F., "Radiocarbon Dating" (Univ. Chicago Press, 1952).
[2] Vries, H. L. de, and Barendsen, G. W., *Physica*, **18**, 652 (1952).
[3] Faltings, V., *Naturwiss.*, **39**, 378 (1952).
[4] Anderson, E. C., and Levi, H., *Kgl. Danske Vidensk. Selskab., Mat.-fys. Medd.*, **27**, No. 6 (1952).

Daily Variation of Amount of Ozone in the Atmosphere

THE improved form of Dobson's spectrophotometer using an *RCA* 1P28 photo-multiplier tube enables measurements of atmospheric ozone to be made with the light from the moon. Dobson's own measurements[1] made at Oxford during November–December, 1948, showed variations of ozone on some nights, and he concluded that they could be attributed to changes in meteorological conditions. As the day-to-day variations of amount of ozone in middle latitudes are large, it would be difficult to find without prolonged observation whether there is any systematic difference between the ozone amounts during day- and night-hours. In low latitudes, however, both the total amount as well as the day-to-day variations are small during a large part of the year, and if a regular daily variation exists as might be expected from the photochemical theory of atmospheric ozone, it could be determined from a short series of observations. Accordingly, observations were made at Mount Abu and Ahmedabad in the period November 1952–April 1953, and these show clearly that there is a substantial increase of ozone during night-hours, as compared to day-hours.

Fig. 1 shows the values of $\log(I/I')$ against μ, the thickness of ozone traversed by the incident light at different zenith-distances of the sun or moon, where I is the intensity of a small ozone-absorbed spectral region near λ 3112 and I' the corresponding intensity near λ 3323 in a less-absorbed region of the spectrum, on four days and succeeding moonlit nights. It will be seen that on each day the mean straight line connecting the night observations has a steeper slope than the line connecting the day observations, indicating a larger quantity of ozone in night.

Table 1. SUMMARY OF OZONE VALUES DURING DAY AND DURING NIGHT. x is the amount of ozone in cm. at S.T.P. No correction has been made for atmospheric haze

Date	Day value of x in cm.	Night value of x in cm.	Difference
29–11–52	0·138	0·163	0·025
30–11–52	0·137	0·162	0·025
1–12–52	0·136	0·160	0·024
2–12–52	0·135	0·157	0·022
22–12–52	0·141	0·171	0·030
23–12–52	0·139	0·172	0·033
24–12–52	0·147	0·174	0·027
26–12–52	0·146	0·188	0·042
27–12–52	0·147	0·191	0·044
28–12–52	0·151	0·170	0·019
29–12–52	0·148	0·184	0·036
30–12–52	0·147	0·177	0·030
1– 1–53	0·141	0·173	0·032
2– 1–53	0·140	0·176	0·036
23– 3–53	0·164	0·207	0·033
27– 3–53	0·166	0·196	0·030
3– 4–53	0·179	0·205	0·026

Table 1 gives the mean day- and night-values of ozone (both uncorrected for haze) on seventeen days and nights. In every instance, the night values are larger than the day values. The average excess during night is 0·030 cm. and the extreme differences are 0·019 cm. and 0·044 cm.

Table 2. OBSERVATIONS WITH λλ 3112 AND 3175

Date	Day-time x	Night-time x With λ 3112	Night-time x With λ 3175
30–11–52	0·137	0·168	0·174
1–12–52	0·137	0·165	0·168
1–12–52	0·136	0·151	0·149
2–12–52	0·135	0·168	0·162
27– 3–53	0·166	0·196	0·197
3– 4–53	0·179	0·205	0·203

Observations made at Ahmedabad on the same night with λ 3112/3323 and λ 3175/3399 show agreeing results. Table 2 gives the comparative values of ozone obtained with the two pairs of wave-lengths.

Fig. 2 shows the values of ozone calculated from the individual observations of sunlight and moon-

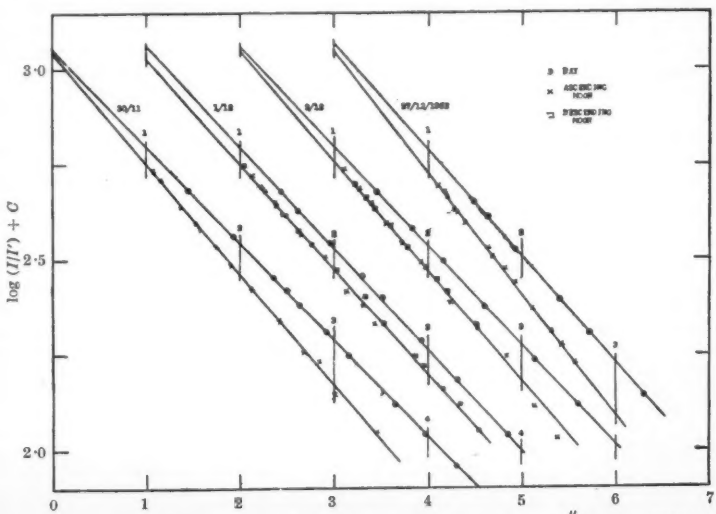


Fig. 1. Values of $\log(I_{3112}/I_{3323}) + C$ plotted against atmospheric ozone path with sunlight and moonlight

light on a number of days. The increase of ozone from the day value to the night value takes place within an hour after sunset. The change from night to day value after sunrise is also rapid. These indicate that the seat of the observed changes is high up in the atmosphere, where the recombination of oxygen atoms and molecules to form ozone after sunset and the photolysis of ozone at sunrise are very rapid. It may be expected that these daily variations of ozone extend to higher latitudes.

Estimates have been made by H. U. Dütsch[2], R. A. Craig[3], D. R. Bates and M. Nicolet[4] and Johnson, Purcell, Tousey and Watanabe[5], of the number of oxygen atoms at different levels in the atmosphere from 30 km. to 90 km. during day-time. From the values calculated by F. S. Johnson and collaborators using the rocket-data of intensity distribution in solar radiation in the ultra-violet, the equilibrium amount of daytime atomic oxygen in the atmosphere can be shown to be approximately 0·020 cm. between 90 and 70 km., and 0·010 cm. between 70 km. and 40 km., with the amount decreasing rapidly at lower heights.

This suggests that the night-time increase of ozone is due to the recombination of 'odd oxygen atoms' with oxygen molecules above the region of maximum ozone concentration and below the main region of Runge–Schumann oxygen absorption.

It may be noted in passing that extraordinarily low values of ozone were recorded at Mount Abu on many days in November and December 1952.

Our thanks are due to Mr. R. N. Kulkarni for taking some of the observations, and to the Indian Council of Scientific and Industrial Research for financial assistance to carry out research work on atmospheric ozone.

A fuller discussion will appear elsewhere.

K. R. Ramanathan
Bh. V. Ramana Murthy

Physical Research Laboratory,
Ahmedabad 9, India.

May 27.

[1] Dobson, G. M. B., *Quart. J. Roy. Meteor. Soc.*, **77**, 488 (1951).
[2] Dütsch, H. U., doctorate thesis (Zurich, 1946).
[3] Craig, R. A., Met. Monogr., *Amer. Meteor. Soc.*, **1**, No. 2 (1950).
[4] Bates, D. R., and Nicolet, M., *J. Geophys. Res.*, **55**, 301 (1950).
[5] Johnson, F. S., Purcell, J. D., Tousey, R., and Watanabe, K., *J. Geophys. Res.*, **57**, 157 (1952).

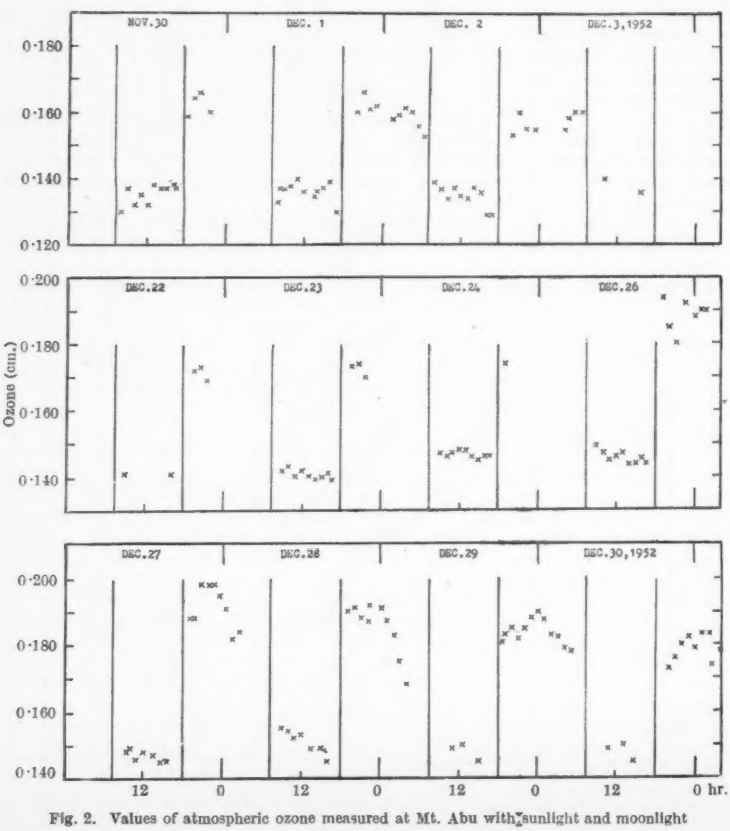


Fig. 2. Values of atmospheric ozone measured at Mt. Abu with sunlight and moonlight

Eddies in Turbulent Jet Diffusion Flames

The turbulent jet diffusion flame may be defined as a flame in which a high-velocity jet of fuel entrains the combustion air by its own momentum. In such flames the rate of combustion is primarily governed by the rate of mixing once the fuel stream has been heated by re-radiation above an ignition temperature. The use of cold models and accepted formulæ for free jets to evaluate the entrainment-rate is accordingly a valuable method of predicting combustion-rates. Such models give time-average mixing ratios at each point in space which may be compared with the analysis of time-average gas samples drawn from the flame, and in each case repeatable regular contours for equal mixing ratios are obtained.

Visual inspection of a luminous flame shows, however, rapid large-scale eddies in the flame structure which correspond to the fluctuating random component of turbulent flow. This is shown in Fig. 1, which was taken on a 3,000 frames/sec. cinéfilm with approximately 1/15,000 sec. exposure. To relate this instantaneous pattern with the smooth time-average pattern given by slow sampling techniques, a 20-sec. exposure has been taken of the same part of the flame with an appropriate neutral density filter. This is shown in Fig. 2, on which the jet angle is 12½°. Empirical formulæ relating mixing length to jet momentum can be adequately based on the time-average conditions, but an understanding of the mechanism of mixing and combustion requires a knowledge of the eddy structure which can be related to hot-wire measurements of fluctuating velocity.

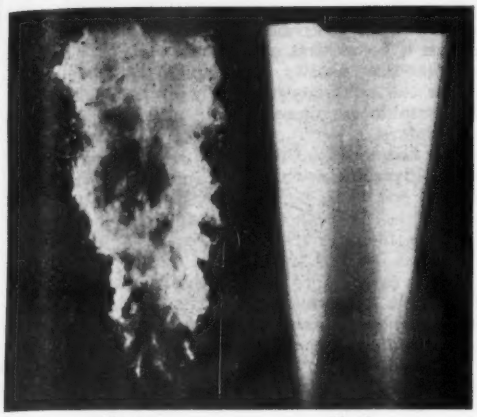


Fig. 1 Fig. 2

These pictures were taken by Mr. R. J. Hayes on a steam 'atomized' oil flame burning with cold air in a refractory chamber: this was the International Flame Radiation Committee's experimental furnace at Ijmuiden.

M. W. Thring
British Iron and Steel Research Association,
11 Park Lane, London, W.1.
June 22.

Antibody Chromatography on an Immunologically Specific Adsorbent

While usual chromatographic methods have not, in general, proved as useful in the separation of closely related proteins as of low molecular weight substances, chromatography on adsorbents which bind only to the specific reactive sites of biologically active proteins may help to fill that need. I wish to report here the feasibility of elution chromatography of an antibody on its specific adsorbent. The antibody proteins are not only separated from the other constituents of serum, but are, in addition, resolved into components which remain active and distinguishable on repeated chromatography.

An adsorbent specific for antibodies homologous to the simple hapten, *p*-azobenzenearsonate, was prepared from powdered cellulose (Solka-Floc BW200, provided by the Brown Company, Berlin, N.H.) by a method similar to that described for an adsorbent for the enzyme, tyrosinase[1]; diazotized *p*-(*p*-aminobenzeneazo)-benzenearsonic acid was coupled to cellulose which had been partially etherified with resorcinol. This approach has been adapted to permit the permanent attachment of a protein, which retains its reactivity to the homologous antibody, to the surface of suitably modified cellulose[2]. The arsonate cellulose binds maximally about 2 mgm. of antibody protein per ml. of packed moist adsorbent. An analogous cellulose preparation in which *p*-azobenzenesulphonate is substituted for the homologous hapten was found not to adsorb detectable amounts of antibody.

Chromatography was carried out by gradient elution, for the reasons given by Alm *et al.*[3], with a specific hapten solution as the eluent. The chromatogram shown in Fig. 1,I was obtained as follows. After a small amount of serum (0·16 ml. serum diluted to 0·7 ml. in saline buffered to *p*H 8·0) was introduced into a column of adsorbent 13 cm. × 0·6 cm., saline was percolated through until the effluent was free of protein, as indicated by the absence of visible turbidity on the addition of trichloracetic acid. The amount of antibody introduced corresponds to roughly 4 per cent of the maximum capacity of the column. The eluting hapten, sodium arsanilate, was then allowed to percolate through the column in increasing concentration at about 0·1 ml./min., and the effluent was collected in fractions of 0·5 ml. The concentration of arsanilate in the effluent is shown in Fig. 1,IV. Trichloracetic acid was added (to a concentration of 10 per cent) to 0·1-ml. aliquots of the fractions; the protein precipitates were washed and measured with the Folin phenol reagent according to the procedure of Lowry *et al.*[4]. When a heterologous hapten, sodium sulphanilate, was used instead of sodium arsanilate, no protein was eluted at any concentration. The remaining portions of fractions 13–16 and fractions 17–24, to the left and right of the dotted line in Fig. 1,I, were combined into two pools and dialysed to remove arsanilate. The results of rechromatographing each pool on the same column as originally used are shown in Fig. 1,II and III. It is evident that each pool retains its position in the chromatogram, and, therefore, that the antibodies of each pool differ in their specific properties. The analytical values in these figures represent, however, the entire protein content rather than aliquots of each fraction, and indicate, therefore, a considerable overall loss of material. The arsanilate concentrations in corresponding fractions of chromatograms II and III, as determined by ultra-violet absorption of the supernatants after protein precipitation, were found to be in good agreement.

The heterogeneity of antibodies has previously been postulated and discussed in studies of hapten inhibition[5]. While the present experiments show that at least two kinds of antibodies homologous to a single hapten can be recognized and isolated, the actual heterogeneity may be much greater, since the pooling of fractions shown in Fig. 1,I into two groups was, of course, arbitrary. The proteins of

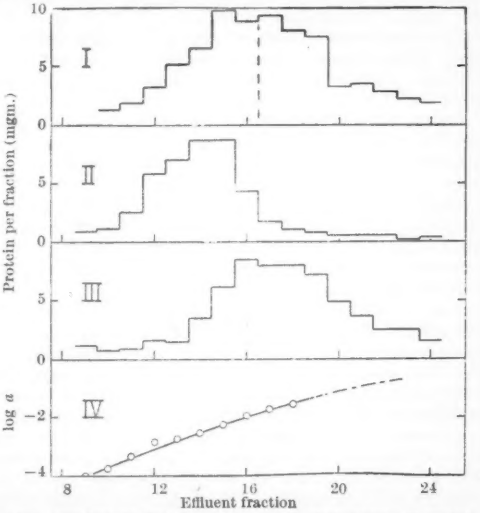


Fig. 1. Gradient elution chromatograms: I, whole serum; II, pooled eluate fractions 13–16 from I; III, pooled eluate fractions 17–24 from I. The arsanilate concentration, *a* (measured in *M*), appearing in each fraction is shown in IV

both pools were isolated in other similar experiments; both formed precipitates with polyhaptenic antigens.

This work was supported by the American Cancer Society and the Jane Coffin Childs Memorial Fund. A supply of rabbit antiserum against bovine globulin-azobenzenearsonate was kindly provided by Prof. D. H. Campbell of the California Institute of Technology.

I am grateful to Mrs. Shulamith Bar-Shany for technical assistance.

L. S. Lerman

Laboratory of Chemical Embryology,
Department of Medicine,
University of Colorado.
Denver, Colorado. June 22.

[1] Lerman, L. S., *Proc. U.S. Nat. Acad. Sci.*, **39**, 232 (1953).
[2] Campbell, D. H., Luescher, E., and Lerman, L. S., *Proc. U.S. Nat. Acad. Sci.*, **37**, 575 (1951).
[3] Alm, R. S., Williams, J. P., and Tiselius, A., *Acta Chem. Scand.*, **6**, 826 (1952).
[4] Lowry, O. H., Rosebrough, N. J., Farr, A. L., and Randall, R. J., *J. Biol. Chem.*, **193**, 265 (1951).
[5] Pauling, L., Pressman, D., and Grossberg, A. L., *J. Amer. Chem. Soc.*, **66**, 784 (1944).

Nosean as a Tracer Mineral

Eight miles south of Land's End stands the well-known Wolf Rock with its important lighthouse. The rock itself is a phonolite, the only one of its kind on the whole of the coast of the British Isles. Its petrography was accurately described by J. J. Harris Teal in 1888 ("British Petrography", Dulau and Co., London).

For our purpose the all-important mineral is nosean, a somewhat soluble sodium aluminium silicate with sodium sulphate; but fortunately it is found in two stages. It occurs as phenocrysts which are useless for the present purpose because of their solubility in sea-water, and it also occurs as inclusions in the felspar sanidine, as minute grains which are thus hermetically sealed within this colourless mineral which is practically as resistant to sea-water as quartz itself. Actually, one can boil small flakes of the sanidine in fairly strong hydrochloric acid without the nosean being destroyed.

Thus the nosean would appear to constitute an ideal tracer mineral for investigating the direction of deep, or bottom, sea-water drift around the British Isles.

Owing to the kindness of Major H. W. Hall, who readily placed his motor yacht *Manihine* at my disposal, we were able to carry out the first test on July 22.

Only one sample has been worked out so far, and that was one taken five miles east of the Wolf Rock at a depth of forty fathoms. It was thought that the work would entail a laborious microscopic examination of the bottom sand grains with the use of density fluids for floating off the sanidine flakes with the nosean. This, however, was found to be unnecessary in this case, for small pebbles of phonolite (about a third of an inch across) were readily separated out with a hand lens. These were crushed and the nosean enclosed in the sanidine recognized without difficulty.

Obviously, if pebbles of the phonolite are carried five miles away by the deep-water drift the minute flakes may be carried even hundreds of miles. Phonolite from the Wolf Rock has been broken up, and the nosean in conjunction with the sanidine is at once recognizable in flakes which are small enough to go through a 200-mesh sieve.

The refractive index of the sanidine is, of course, below that of the canada balsam, while that of the nosean is below that of the sanidine. This, coupled with the low density of the phonolite itself (2·54), makes the work comparatively simple and gives an indisputable diagnosis.

A. G. Lowndes

The Laboratory, Citadel Hill,
Plymouth. July 31.

Milk Yield of Hill Ewes

In the early stages the growth of the lamb is largely dependent on the milk yield of its dam. In hill sheep, where the environment constitutes the limiting factor to production, a study of the milking capacity of the ewe would seem to be of special interest, as it forms a large part of the lamb's environment at a most important period of growth.

Comparatively little work has been done on the lactation of non-dairy breeds of sheep, especially hill sheep. Some of the most extensive studies made on this problem are those by Bonsma in South Africa[1] and Wallace in Cambridge[2], although the sheep studied were not under natural conditions. Studies of the milk yields of sheep on pasture have been made by Barnicoat *et al.*[3] in New Zealand.

In the spring of 1953, an experiment was started at the University College of North Wales to study the milk-yielding capacity of Welsh Mountain ewes, both under their normal hill conditions and after being drafted to the lowland.

Previous workers have usually obtained estimates of the ewe's milk yield by weighing the lamb before and after suckling at various intervals in a weekly 24-hr. period. Between sucklings the ewes and the lambs were separated. At Bangor, however, the separation of the ewe from the lamb was regarded as likely to be a disturbing factor, which might seriously affect milk yield, and an attempt was made to devise a method whereby the lamb was prevented from suckling, and at the same time allowing both ewes and lambs to go out on pasture together in between suckling periods. This was achieved by fitting the ewes with a harness which effectively prevented the lamb from reaching the ewe's udder, and at the same time was both comfortable for the ewe and easy to manipulate at suckling time.

A pilot experiment using eight pedigree Welsh Mountain sheep kept on the lowland was first carried out early in the year to develop the required technique. The experiment proper was started early in April using thirty-two randomly selected hill ewes with single ewe lambs on 'ffridd' or 'inbye' land at about 1,000 ft. above sea-level. Mean daily yields during the six weeks of the experiment were 31·79 ± 6·04 oz. for the hill ewes compared with 47 oz. for the pedigree ewes during a shorter period. A preliminary analysis of this year's results gave a high correlation coefficient ($r = + 0{\cdot}79$) between the milk yield of the ewe and the growth of the lamb during the first month, demonstrating the importance of the dam's milk yield to the young lamb. Significant correlations were also obtained between the milk yield of the ewe and the birth weight of the lamb ($r = + 0{\cdot}51$) and the weight of the ewe at tupping time ($r = + 0{\cdot}36$). Although there appeared to be a correlation between milk yield and some fleece characters these were not highly significant, and further work is needed to prove any relationship.

These results, of course, being for one season only, must be confirmed and extended by further work before any conclusions are reached.

It is hoped to be able to increase the numbers used in the experiment in future, and to study the relationship of milk yield to such factors as fleece type, genetic influences, weight (both at lambing and tupping time), age, time of lambing and udder measurements. Some of the ewes included in this year's experiment will be drafted on to the lowland in order to study the effect on milk yield of the change from a poor to a good environment, as normally occurs when the hill ewe is drafted to the lowland.

Some observations have also been made on the quality of the milk, and it is hoped to extend these. Finally, the effect of milk yield and other factors on the lamb will be studied.

J. B. Owen

School of Agriculture,
University College of North Wales,
Bangor.
June 30.

[1] Bonsma, F. N., Publication No. 48, University of Pretoria (1939).
[2] Wallace, L. R., *J. Agric. Sci.*, **38**, Part 2 (1948).
[3] Barnicoat, Logan and Grant, *J. Agric. Sci.*, **39**, Parts 1 and 2 (1949).

Influence of Inorganic Sulphate on the Copper–Molybdenum Interrelationship in Sheep

In 1945 we published the first experimental observations[1] which showed that the storage of copper in the livers of sheep and cattle could be significantly reduced by an increase in the molybdenum intake, and we suggested that an abnormally high molybdenum intake may possibly explain, among other things, the seeming anomaly of copper deficiency in sheep-grazing pastures which show by ordinary chemical analysis a copper concentration within normal limits.

Since then a number of workers have studied the copper–molybdenum interrelationship in animal metabolism. Observations on this interrelationship are discussed in a number of the papers in the symposium on copper metabolism edited by McElroy and Glass[2], and more recently the literature has been reviewed by Marston[3].

Many of the observations and experimental results have been conflicting[3–4], and some workers[5] have not been able to confirm our original results.

In association with our studies on chronic copper poisoning in sheep[6,7], we have continued our observations on the effects of molybdenum on copper metabolism; and we believe that in the results of our more recent studies may lie the explanation of many of the anomalies and conflicting observations.

With sheep under experimental conditions, we have shown that, for a particular dietary regime, which included a total daily intake of 10 mgm. of copper, there is a quantitative relationship between the amount of molybdenum added to the diet and the reduction in the amount of copper stored in the liver. Under these conditions, on comparing groups of sheep on successively greater daily intakes of molybdenum, all on a diet of equal parts by weight of chaffed lucerne hay and chaffed oaten hay, it was found that progressively less copper was stored in the liver as the molybdenum intake was increased from 0·4 mgm. to 10 mgm. per day. Further increases in the molybdenum intake, up to 100 mgm. per day, had no greater effect in limiting the amount of copper stored.

On this mixed diet, the level of molybdenum maintained in the circulating blood was increased as the molybdenum intake was increased. When these chaffed hays were fed separately to sheep, all on the same molybdenum intake, it was observed that the blood-molybdenum level was approximately ten times higher in the sheep on the oaten diet than in those on the lucerne diet. A comparison of groups of sheep[8], all on intakes of 10 mgm. of molybdenum and 15 mgm. of copper per day, but fed on the separate chaffed hays or on mixtures of several different proportions of these, showed that the greatest limitation of copper storage in the liver was obtained in sheep fed on the pure lucerne diet. Molybdenum appeared to exert no limiting effect at all in sheep on the pure oaten diet, and for the several diet mixtures the amount of copper stored in the liver and the level of molybdenum in the blood were directly proportional to the amount of chaffed oaten hay in the mixture.

We thus have the apparently anomalous position that as the blood-molybdenum level is raised by increasing the molybdenum intake of sheep, all on the same mixed diet, the amount of copper stored in the liver is progressively decreased; but as the blood-molybdenum level is raised by increasing the proportion of chaffed oaten hay in the diet of sheep, all on the same molybdenum intake, the amount of copper stored in the liver is progressively increased.

In a subsequent experiment of six months duration we have shown that with two groups of sheep, both having a total copper intake of 10 mgm. per day and a molybdenum intake of 0·5 mgm. per day, one group fed on chaffed lucerne hay and the other on chaffed oaten hay, the copper content of the livers of both groups increased. However, even at this low level of molybdenum intake, the group on the lucerne diet stored significantly less copper than the group on the oaten diet; in the former there was a gain of 55 mgm., increasing during the experiment from 39 mgm. to 94 mgm., and the latter 97 mgm., increasing from 40 mgm. to 137 mgm.

With two similar groups on a molybdenum intake of 10 mgm. per day, there was a loss of 13 mgm. (from 41 mgm. to 28 mgm.) of copper from the liver in the group on the lucerne diet, but the greater intake of molybdenum did not significantly affect the rate of copper storage in the group on the oaten diet; it increased by 70 mgm. (from 38 mgm. to 108 mgm.).

By fractionation of this chaffed lucerne hay we have shown[9] that the whole of its effect on the level of molybdenum in the blood is due to its content of inorganic sulphate which is present in amounts of the order of 0·3 per cent. The chaffed oaten hay contains less than one-tenth of this amount.

To determine whether the difference in inorganic sulphate content of the two diets was also responsible for the difference between them in enabling molybdenum to exert its limiting effect on copper storage, a further experiment has been carried out. A sufficient quantity of copper sulphate and ammonium molybdate was added to the diets of three groups of sheep to bring both the copper and molybdenum intakes up to 10 mgm. per day in each group. One group was fed on chaffed oaten hay, one on chaffed lucerne hay, and the third group on chaffed oaten hay with 4·5 gm. potassium sulphate per kilogram added to

it. After a period of three months it was found that the first group had increased its liver-copper storage, but both the other two groups had lost copper from the liver and the amounts lost were substantially the same whether the diet was chaffed lucerne hay or chaffed oaten hay plus sulphate. In the first group liver-copper was increased by 19 mgm. (from 76 mgm. to 95 mgm.); it was decreased in the second group by 25 mgm. (from 76 mgm. to 51 mgm.), and in the third group by 26 mgm. (from 66 mgm. to 40 mgm.).

Inorganic sulphate is, therefore, required to enable molybdenum to exert a limiting effect on the storage of copper in the liver of sheep, and the difference in inorganic sulphate content of chaffed lucerne hay and chaffed oaten hay constitutes the major difference between them in their effect on the control of copper storage by molybdenum.

It seems, in the light of these observations and the wide limits between which both the inorganic sulphate and molybdenum content of natural pastures may vary, that the conditions under which copper deficiencies in grazing animals have been reported to occur should be re-examined. Furthermore, it would now appear that studies on molybdenum metabolism, especially on its retention and excretion, are valueless unless the inorganic sulphate intake of the animal is also taken into consideration.

A. T. Dick

Division of Animal Health and Production,
Animal Health Research Laboratory,
Commonwealth Scientific and
Industrial Research Organization,
Parkville, N.2,
Victoria, Australia.

June 19.

[1] Dick, A. T., and Bull, L. B., *Aust. Vet. J.*, **21**, 70 (1945).
[2] McElroy, W. D., and Glass, B., "Copper Metabolism. A Symposium on Animal, Plant and Soil Relationships" (Johns Hopkins Press, Baltimore, 1950).
[3] Marston, H. R., *Physiol. Rev.*, **32**, 66 (1952).
[4] Stewart, Jas., Farmer, V. C., and Mitchell, R. L., *Nature*, **157**, 442 (1946).
[5] Green, H. H., Proc. Specialist Conference in Agriculture, Australia, 1949, 293 (H.M.S.O., London, 1951).
[6] Bull, L. B., Proc. Specialist Conference in Agriculture, Australia, 1949, 300 (H.M.S.O., London, 1951).
[7] Albiston, H. E., Bull, L. B., Dick, A. T., and Keast, J. C., *Aust. Vet. J.*, **16**, 233 (1940).
[8] Dick, A. T., *Aust. Vet. J.*, **28**, 30 (1952).
[9] Dick, A. T., *Aust. Vet. J.*, **29**, 18 (1953).

Absence of the Sickle Cell Trait in Seventy-two Australian Aboriginals

The Veddoids of southern India have many physical features in common with the Australian aboriginals, and the Indian anthropologist, Dr. B. S. Guha, has actually suggested that the term 'Veddoid' or 'Veddian' should be replaced by the word 'Proto-Australoid'[1]. Whether the Veddoid element is equally strong in all Australian aboriginals is not certain. Birdsell[2] divides the Australian aboriginals into three groups; that in the Northern Territories is considered to have more Veddoid connexions than the other two, which are more intimately related to Negritos and Europoid Ainus respectively.

When one of us, jointly with Miss M. Cutbush[3], discovered the sickle cell trait to be present with a high incidence in the Veddoids of southern India, it was also found that their rhesus chromosome distribution showed features differing from those of other Indian populations, and more like those found in South-East Asia, Australasia, and especially in the Australian aboriginals. The rhesus chromosome *CDE* (R_2), which is rare, or absent, in most parts of the world, exists in Australian aboriginals at a frequency of several per cent rather than per mille[4,5], and was found at a frequency of 4·43 per cent in 156 unrelated south Indian Veddoids. This is the highest R_2 frequency reported up to now outside Australia, and it was thus of interest to see whether the sickle cell trait could be traced in the Australian aboriginals.

From Birdsell's "Maps of Races"[2], it would seem that there is a Negrito influence in the north-west of Australia. This is relevant, because one of us has recently found that the Andamanese Negritos (52 pure Onges of Little Andaman and 16 Andamanese of mixed ancestry) show no sickle cell trait. However, everyone, including Birdsell, is agreed that the Carpentarian (Veddoid) element is strongly represented all over the northern half of Australia, including those parts from which we intended to obtain our blood samples. We arranged to have the blood of seventy-two Australian aboriginals from Queensland flown to London to be examined for the sickle cell trait. Fifty-seven of the donors were of unmixed Australian ancestry, according to their own accounts and also to their appearance. The bloods of fifty-four were collected on a visit to the Mona-Mona Mission, and the remainder of the samples was obtained at the Cairns Base Hospital. The blood was taken in 'vacunes' and arrangements were made for speedy transport with cooling on the way, so that they were examined in London less than ten days after they had been obtained in Australia. There was no visible hæmolysis. The bloods were sterile, and it is known from the experience of testing blood samples sent under similar conditions from Africa and Greece that the sickle cell trait can be demonstrated for at least two to three weeks after the arrival of the bloods in London. All samples were examined both by incubation with sodium-metabisulphite and with sodium-hydrosulphite[6,7]. None of the blood samples was found to show the sickle cell trait.

The examination of blood groups of Australian aboriginals is carried out so adequately in Australia that we felt it superfluous to extend our investigation into this field. However, to test the freshness of the samples and to verify the presence of the R_2 chromosome in our particular group of aboriginals, Miss E. W. Ikin, of the Blood Group Reference Laboratory, kindly determined a number of blood group systems, and confirmed that the blood group distribution, which included the presence of the R_2 chromosome, agreed with that to be expected from previous reports on the blood groups of Australian aboriginals.

W. R. Horsfall

Commonwealth Health Laboratory,
Cairns, Australia.

H. Lehmann

St. Bartholomew's Hospital,
London, E.C.1.

June 27.

[1] Guha, B. S., "An Outline of the Racial Ethnology of India" (published by the Indian Science Congress Association, Calcutta, 1937).
[2] Birdsell, J. B., Cold Spring Harbor Symposia on Quantitative Biology, **15**, 259 (1950).
[3] Lehmann, H., and Cutbush, M., *Brit. Med. J.*, **1**, 404 (1952); *Trans. Roy. Soc. Trop. Med. and Hyg.*, **46**, 380 (1952).
[4] Simmons, R. T., and Graydon, J. J., *Med. J. Austral.*, **2**, 113 (1948).
[5] Sanger, R., Walsh, R. J., and Kay, M. P., *Amer. J. Phys. Anthrop.*, N.S. **9**, 71 (1951).
[6] Daland, G. A., and Castle, W. B., *J. Lab. Clin. Med.*, **33**, 1082 (1948).
[7] Williams, A. W., and Mackey, J. P., *J. Clin. Path.*, **2**, 141 (1949).

FORTHCOMING EVENTS

*(Meetings marked with an asterisk * are open to the public)*

Monday, October 5

SOCIETY OF ENGINEERS (at the Geological Society, Burlington House, Piccadilly, London, W.1), at 5.30 p.m.—Mr. S. F. Smith: "Surface Finish and its Measurement by Electronic Methods".

SOCIETY OF CHEMICAL INDUSTRY, LONDON SECTION (joint meeting with the LONDON SECTION, ROYAL INSTITUTE OF CHEMISTRY, in the Chemical Society's Rooms, Burlington House, Piccadilly, London, W.1), at 6.30 p.m.—Dr. A. J. E. Welch: "Recent Developments in the Chemistry of Metal Oxides".

Tuesday, October 6

INSTITUTION OF CHEMICAL ENGINEERS (at the Geological Society, Burlington House, Piccadilly, London, W.1), at 5.30 p.m.—Papers on "Liquid–Liquid Extraction".

Wednesday, October 7

INSTITUTE OF FUEL (in the Lecture Hall, Institution of Mechanical Engineers, Storey's Gate, St. James's Park, London, S.W.1), at 5.30 p.m.—Dr. Harold Hartley: "The Domestic Appliance Industry and Fuel Usage". (The Melchett Lecture for 1953.)*

THE EUGENICS SOCIETY (at the Royal Society, Burlington House, Piccadilly, London, W.1), at 5.30 p.m.—Mr. James Shields: "Personality Differences and Neurotic Traits in Normal Twin School Children".*

SOCIETY OF PUBLIC ANALYSTS AND OTHER ANALYTICAL CHEMISTS (at the Chemical Society, Burlington House, Piccadilly, London, W.1), at 7 p.m.—Discussion on "Destruction of Organic Matter". Mr. G. Middleton and Dr. R. E. Stuckey: "The Preparation of Biological Material for the Determination of Trace Metals. Part II. A Method for the Destruction of Organic Matter in Biological Material"; Dr. H. C. Lockwood: "Determination of Lead in Foodstuffs".

Thursday, October 8

LINNEAN SOCIETY OF LONDON (at Burlington House, Piccadilly, London, W.1), at 4.30 p.m.—General Meeting. Dr. K. A. Kermack: "An Ancestral Crocodile from South Wales"; Miss W. M. A. Brooke: "The Vegetation of Wet Districts of the Bolivian Andes from 10,000 ft. to the Snowline".

INSTITUTION OF ELECTRICAL ENGINEERS (at Savoy Place, London, W.C.2), at 5.30 p.m.—Mr. H. Bishop: Inaugural Address as President.

Friday, October 9

ROYAL ASTRONOMICAL SOCIETY (at Burlington House, Piccadilly, London, W.1), at 4.30 p.m.—Scientific Papers.

TELEVISION SOCIETY (at the Cinematograph Exhibitors' Association, 164 Shaftesbury Avenue, London, W.C.2), at 7 p.m.—Mr. C. B. B. Wood: "Recording Television Programmes".

Saturday, October 10

INSTITUTION OF CHEMICAL ENGINEERS, NORTH-WESTERN BRANCH (joint meeting with the CHEMICAL ENGINEERING GROUP and the MANCHESTER SECTION of the SOCIETY OF CHEMICAL INDUSTRY, in the Reynolds Hall, College of Technology, Sackville Street, Manchester), at 3 p.m.—Mr. Norman Swindin: George E. Davis Memorial Lecture.

APPOINTMENTS VACANT

APPLICATIONS are invited for the following appointments on or before the dates mentioned:

ASSISTANT LECTURER (Grade A) IN APPLIED SCIENCES at the Constantine Technical College, Middlesbrough, to teach applied sciences in craft courses having a biological and chemical bias—The Director of Education, Woodlands Road, Middlesbrough (October 10).

ASSISTANT (preferably with honours degree in science or agriculture) IN THE CHEMISTRY DEPARTMENT, for work mainly connected with plant nutrition and soils—The Secretary, West of Scotland Agricultural College, 6 Blythswood Square, Glasgow, C.2 (October 12).

SENIOR LECTURER OR LECTURER IN PHYSICS at the University College of the Gold Coast—The Secretary, Inter-University Council for Higher Education in the Colonies, 1 Gordon Square, London, W.C.1 (October 12).

LECTURER (with degree in electrical engineering, and able to teach up to final degree standard) IN ELECTRICAL ENGINEERING—The Principal, Wigan and District Mining and Technical College, Wigan (October 14).

DEMONSTRATORS (3) (with first- or second-class honours degree in chemistry) IN THE DEPARTMENT OF ORGANIC CHEMISTRY—The Registrar, The University, Liverpool (October 24).

PHYSICISTS (with H.S.C. (Science) or equivalent, and experience or interest in one of the following desirable: electronics, particularly as applied to counter circuits and recording of high speed transient phenomena; ultra high speed photography; electronic and mechanical instrumentation; general physics of shock waves; physical metallurgy) at Ministry of Supply Research Stations near Sevenoaks and Southend, for work chiefly concerned with physical and physico-chemical characteristics of detonation and associated phenomena—The Ministry of Labour and National Service, Technical and Scientific Register (K), 26 King Street, London, S.W.1, quoting A.246/53A (October 24).

POLYMER CORPORATION RESEARCH STUDENTSHIP IN CHEMISTRY—The Registrar, University College of North Staffordshire, Keele, Staffordshire (October 31).

PRINCIPAL (with good honours degree and teaching experience in science, engineering or arts, and experience of administration with high degree of responsibility) OF THE NIGERIAN COLLEGE OF ARTS, SCIENCE AND TECHNOLOGY—The Secretary, Advisory Committee on Colonial Colleges, 1 Gordon Square, London, W.C.1 (October 31).

LECTURER (preferably with a special interest in some branch of applied mathematics) IN MATHEMATICS—The Registrar, College of Technology, Manchester 1 (November 2).

CHEMIST, RESEARCH OFFICER OR SENIOR RESEARCH OFFICER (with honours degree in chemistry or equivalent, and research training or experience in physical or organic chemistry) in the South African Council for Scientific and Industrial Research, Bituminous Binder Research Unit, Pretoria, to carry out original studies on the weathering of tar and bitumen binders used in bituminous road surfacing materials, with the object of improving their durability and road performance, and supervise the analytical control work associated with the laboratories full-scale road work—The South African Scientific Liaison Officer, Africa House, Kingsway, London, W.C.2 (Pretoria, November 3).

CHAIR OF MORBID ANATOMY tenable at St. Mary's Hospital Medical School—The Academic Registrar, University of London, Senate House, London, W.C.1 (November 4).

UNIVERSITY DEMONSTRATOR (with honours degree in pure science or agricultural chemistry with specialization in soil science) IN SOIL SCIENCE—The Secretary, School of Agriculture, The University, Cambridge (November 7).

ASSISTANT DIRECTOR (graduate in engineering, physics, chemistry or microbiology, and experience of research in the preservation, processing and transport of food, preferably fish) AT THE FISHING INDUSTRY RESEARCH INSTITUTE, Cape Town—The Secretary, P.O. Box 1233, Cape Town, South Africa (November 16).

ABSTRACTOR (science graduate, and preferably with knowledge of textile technology, and capable of abstracting technical and scientific papers from foreign, particularly German, periodicals) IN THE INFORMATION DEPARTMENT, British Cotton Industry Research Association—The Director, British Cotton Industry Research Association, Shirley Institute, Didsbury, Manchester 20.

BIOPHYSICIST OR PHYSICIST, a PHYSICAL CHEMIST, and a BIOCHEMIST (with honours degree and preferably with postgraduate experience) for work with a small research unit investigating problems concerned with new methods for detecting the location of enzymes in animal tissues and cells—The Secretary, Courtauld Institute of Biochemistry, Middlesex Hospital Medical School, London, W.1.

ELECTRICAL ENGINEERS (preferably graduates or Corporate Members of the Institutions of Electrical or Mechanical Engineers, and with sound training and appropriate experience) with the Central Electricity Board, Federation of Malaya—The Crown Agents for the Colonies, 4 Millbank, London, S.W.1, quoting M2C/2877/0/TA.

ELECTRICAL ENGINEERS and PHYSICISTS, (*a*) Scientific Officer grade (with first- or second-class honours degree or equivalent in physics or light electrical engineering); (*b*) Experimental Officer and Assistant Experimental Officer grade (H.S.C. Science or equivalent), at the Ministry of Supply Radar Research Establishment, Malvern, for research and development work on radio and electronic equipment —The Ministry of Labour and National Service, Technical and Scientific Register (K), 26 King Street, London, S.W.1, quoting A.254/53A.

ELECTRONIC ENGINEERS and PHYSICISTS (with first- or second-class honours degree or equivalent in physics or electrical engineering), at the Atomic Weapons Research Establishment, Sevenoaks, Kent, for (*a*) Design, development and engineering of special electronic instruments, (*b*) Research, development and implementation of electronic equipment for special telemetry project, and responsibility during periodic field trials—The Ministry of Labour and National Service, Technical and Scientific Register (K), 26 King Street, London, S.W.1, quoting A.255/53A.

ENGINEER (preferably with telecommunications degree) in the Ministry of Supply, Fort Halstead, Kent, to assist design and prototype production of electronic equipment in the audio, R.F. and U.H.F. bands—The Ministry of Labour and National Service, Technical and Scientific Register (K), 26 King Street, London, S.W.1, quoting D.377/53A.

GEOLOGIST (with first- or good second-class honours degree in geology, and preferably with more than two years postgraduate experience) in Fiji, to assist the Senior Geologist to map, geologically in detail, mineralized areas in the Colony—The Director of Recruitment, Colonial Office, Great Smith Street, London, S.W.1, quoting CDE/105/49/01.

GRADUATE (preferably with some knowledge of the steel industry) to undertake research on the flow of technical information in the steel industry—The Personnel Officer, British Iron and Steel Research Association, 11 Park Lane, London, W.1, quoting "Information".

LECTURER and an ASSISTANT LECTURER (with special knowledge of cytology, genetics, ecology, taxonomy or anatomy) IN BOTANY—The Registrar, The University, Nottingham.

SCIENTIFIC OFFICER or SENIOR SCIENTIFIC OFFICER (with first- or second-class honours degree, preferably in psychology or social science, and two or three years research experience, and ability to deal with a wide range of subjects) IN THE DEPARTMENT OF SCIENTIFIC AND INDUSTRIAL RESEARCH, Headquarters Office, for work on human factors in industry—The Ministry of Labour and National Service, Technical and Scientific Register (K), 26 King Street, London, S.W.1, quoting G.309/53A.

SENIOR LECTURER AND HEAD (with professional and teaching experience, and preferably with experience in structural theory and design) OF THE DEPARTMENT OF CIVIL ENGINEERING—The Secretary and Registrar, The University, Southampton.

SENIOR LECTURER IN CHEMICAL ENGINEERING at the Technical College, Bradford—The Director of Education, Town Hall, Bradford.

SENIOR RESEARCH OFFICER or PRINCIPAL SCIENTIFIC OFFICER (with university honours degree, and special training and research experience in fuel technology or in applied chemistry, or equivalent qualifications) IN THE COMMONWEALTH SCIENTIFIC AND INDUSTRIAL RESEARCH ORGANIZATION, Coal Research Section, Sydney, N.S.W., to undertake investigations into the properties of coal with respect to the formation of gas, coke and chemical products upon carbonization —The Chief Scientific Liaison Officer, Australian Scientific Liaison Office, Africa House, Kingsway, London, W.C.2, quoting 480/107.

SENIOR SCIENTIFIC OFFICER or SCIENTIFIC OFFICER (with first- or second-class honours degree in bacteriology or microbiology, or degree including chemistry and biology followed by postgraduate diploma in bacteriology) IN THE DEPARTMENT OF SCIENTIFIC AND INDUSTRIAL RESEARCH, Water Pollution Research Laboratory, Watford, for research on bacteriological problems in work on pollution of rivers and treatment of water, sewage and trade wastes—The Ministry of Labour and National Service, Technical and Scientific Register (K), 26 King Street, London, S.W.1, quoting G.308/53A.

SENIOR SCIENTIFIC OFFICER or SCIENTIFIC OFFICER (with first- or second-class honours degree in inorganic or physical chemistry) IN THE DEPARTMENT OF SCIENTIFIC AND INDUSTRIAL RESEARCH, Water Pollution Research Laboratory, Watford, and subsequently at Stevenage, for research on the rates under different conditions, of reactions occurring in the polluted Thames estuary, including reduction of sulphates and oxidation of sulphides—The Ministry of Labour and National Service, Technical and Scientific Register (K), 26 King Street, London, S.W.1, quoting F.477/53A.

SENIOR SCIENTIFIC OFFICERS and SCIENTIFIC OFFICERS (with first- or second-class honours degree in a scientific subject (including engineering) or equivalent) IN THE MINISTRY OF FUEL AND POWER, Chief Scientist's Division, London, for duties concerned with conceiving and developing novel sources and uses of fuel and power—The Ministry of Labour and National Service, Technical and Scientific Register (K), 26 King Street, London, S.W.1, quoting F.259/53A.

TECHNICAL ASSISTANT (with some training and experience in topographical draughtsmanship and general cartography) IN THE DEPARTMENT OF GEOGRAPHY—Prof. Peel, Department of Geography, The University, Leeds.

REPORTS and other PUBLICATIONS

(not included in the monthly Books Supplement)

Great Britain and Ireland

United States No. 2 (1953). Proposed Arrangements for the Administration of the Marshall Scholarship Scheme. Pp. 9. (Cmd. 8846.) (London: H.M. Stationery Office, 1953.) 6*d*. net. [147

Eighth Report from the Select Committee on Estimates, together with the Minutes of Evidence taken before Sub-committee E and Appendices. Session 1952–1953. Schools. Pp. xxii+233. (186.) (London: H.M. Stationery Office, 1953.) 9*s*. net. [147

Colonial Office. The Colonial Territories 1952–53. Pp. ix+157. (Cmd. 8856.) (London: H.M. Stationery Office, 1953.) 5*s*. net. [147

Colonial Development Corporation. Annual Report and Statement of Accounts for Year to 31.12.52. Pp. vii+62. (158.) (London: H.M. Stationery Office, 1953.) 3*s*. 6*d*. net. [147

Careers in Chemical Engineering. Pp. 12 (4 plates). (London: Institution of Chemical Engineers, 1953.) 2*s*. [147

British Rubber Producers Research Association. Publication No. 177: Determination of Particle Size in Natural Latex. By Dr. E. G. Cockbain. Pp. 297–302. Publication No. 178: Journal of Polymer Science. Vol. 10, No. 3: Rupture of Rubber, Part 1: Characteristic Energy for Tearing. By R. S. Rivlin and A. G. Thomas. Pp. 291–318. Publication No. 179: The Velocity and Temperature Dependence of Rubber Friction. By A. Schallamach. Pp. 386–392. (London: British Rubber Producers Research Association, 1953.) [147

Department of Scientific and Industrial Research. Geological Survey and Museum. British Regional Geology: Northern England. Third edition. By T. Eastwood, with some additions by F. M. Trotter and W. Anderson. Pp. vi+71+8 plates. (London: H.M. Stationery Office, 1953.) 4*s*. net. [147

The Behaviour of Aluminium Alloy Riveted Joints. By Prof. A. J. Francis. (Research Report No. 15.) Pp. 96. (London: Aluminium Development Association, 1953.) 7*s*. 6*d*. [147

Sixth Annual Report of the Advisory Council on Scientific Policy (1952–1953). Pp. iv+10. (Cmd. 8874.) (London: H.M. Stationery Office, 1953.) 6*d*. net. [147

Department of Scientific and Industrial Research. Report of the Road Research Board, with the Report of The Director of Road Research for the year 1952. Pp. vi+88+12 plates. (London: H.M. Stationery Office, 1953.) 4*s*. 6*d*. net. [147

The Third Annual Report on the Fulbright Program in the United Kingdom and Colonial Territories, 1951–52. Pp. 70. (London: United States Educational Commission in the United Kingdom, 1953.) [147

Privy Council. Agricultural Research Council. The Agricultural Research Service. Pp. vi+54. (London: H.M. Stationery Office, 1953.) 2*s*. 6*d*. net. [147

Christianity in an Age of Science. By Prof. C. A. Coulson. (Riddell Memorial Lectures, Twenty-fifth Series.) Pp. ii+53. (London: Oxford University Press, 1953.) 5*s*. net. [177

National Institute of Agricultural Botany. Thirty-Third Report and Accounts, 1952. Pp. 44. (Cambridge: National Institute of Agricultural Botany, 1953.) [177

Committee of Privy Council for Medical Research. Report of the Medical Research Council for the Year 1951–1952. Pp. iv+241. (Cmd. 8876.) (London: H.M. Stationery Office, 1953.) 6*s*. 6*d*. net. [177

Synthetic Detergents. Pp. 16. (London: Unilever, Ltd., 1953.) [207

Rothamsted Experimental Station, Harpenden. (Lawes Agricultural Trust.) Report for 1952. Pp. 211. (St. Albans: Gibbs and Bamforth, Ltd., 1953.) 7*s*. 6*d*. [207

The National Formulary 1952. First Amendment 1953. Pp. 16. (London: The Pharmaceutical Press, and British Medical Association, 1953.) 6*d*. [207

Agricultural Research Council. A.R.C. Report Series No. 13: Antibiotics in Pig Food. Pp. 20. (London: H.M. Stationery Office, 1953.) 1*s*. 6*d*. net. [207

Department of Scientific and Industrial Research. Road Research Laboratory. Road Research Technical Paper No. 26: The Braking Performance of Motor Vehicles and Brake Testing. By Dr. H. J. H. Starks. Pp. vi+32. (London: H.M. Stationery Office, 1953.) 2*s*. net. [207

Medical Research Council; Ministry of Health; Department of Health for Scotland. Central Health Services Council Advisory Committee on Medical Research in Scotland. Clinical Research in Relation to the National Health Service. Pp. 23. (London: H.M. Stationery Office, 1953.) 9*d*. net. [207

Department of Scientific and Industrial Research and Fire Offices' Committee. Joint Fire Research Organization. References to Scientific Literature on Fire, Part 5, 1951. By Miss E. M. Shakeshaft, Miss K. C. Stringer, Miss B. F. W. Baxter, and Miss I. G. Wolanska. (Library Bibliography No. 5/Part 5.) Pp. 60. (Boreham Wood: Fire Research Station, 1953.) [207

A Short Philosophy for Junior Management. Pp. 46. (London: F. J. Lyons, 1953.) [217

Department of Scientific and Industrial Research. Report of the Chemistry Research Board, with the Report of the Director of the Chemical Research Laboratory for the Year 1952. Pp. iv+120+4 plates. (London: H.M. Stationery Office, 1953.) 4*s*. 6*d*. net. [217

Ministry of Transport. Committee on the Prevention of Pollution of the Sea by Oil. Pp. v+50. (London: H.M. Stationery Office, 1953.) 2*s*. net. [217

Other Countries

The British Caribbean Meteorological Service. First Annual Report—1952. Pp. 23. (Trinidad: Government Printing Office, 1953.) 24 cents. [67

Southern Rhodesia. Report of the Director, Geological Survey, for the Year 1952. Pp. 8. (Salisbury: Geological Survey Office, 1953.) [67

Institute of Theoretical Astrophysics, Blindern–Oslo Report No. 3: Solar Radio Noise Recording Equipment Built for the Solar Observatory at Harestua. By Gunnar Eriksen. Pp. ii+18. (Blindern: Akademisk Trykningssentral, 1953.) [67

Bernice P. Bishop Museum. Bulletin 210: Report of the Director for 1952. By Edwin H. Bryan, Jr. Pp. 40+1 plate. (Honolulu: Bernice P. Bishop Museum, 1953.) [67

State of California, Department of Fish and Game. Marine Fisheries Branch. Fish Bulletin No. 91: Common Ocean Fishes of the California Coast. By Phil M. Roedel. Pp. 184. (San Francisco: Department of Fish and Game, 1953.) [67

Symposium on some Aspects of Microbial Metabolism given at Research Conference for Biology and Medicine of the Atomic Energy Commission. Sponsored by the Biology Division, Oak Ridge National Laboratory. Pp. 282. (Philadelphia: Wistar Institute of Anatomy and Biology, 1953.) [67

Koninklijke Nederlandse Akademie van Wetenschappen. Proceedings. Vol. 56, No. 3. Series A: Mathematical Sciences. Pp. 195–302. Series B: Physical Sciences. Pp. 203–302. Series C: Biological and Medical Sciences. Pp. 301–408+13 plates. (Amsterdam: North-Holland Publishing Company, 1953.) [67

Technology Reports of the Osaka University. Vol. 3, Nos. 55–73. March 1953. Pp. iv+214. (Osaka: Osaka University, 1953.) [97

Annual Reports for 1949–51 of the Smallholders' Advisory Service of the Rubber Research Institute of Malaya. Pp. 33. (Kuala Lumpur: Rubber Research Institute of Malaya, 1953.) [97

World Health Organization. Technical Report Series No. 66: Joint ILO/WHO Committee on Occupational Health. Second Report. Pp. 30. (Geneva: World Health Organization; London: H.M. Stationery Office, 1953.) 1*s*. 6*d*.; 0.20 dollars; 0.80 Sw. francs. [97

World Health Organization. Technical Report Series No. 67: Joint FAO/WHO Expert Committee on Brucellosis. Second Report. Pp. 34. (Geneva: World Health Organization; London: H.M. Stationery Office, 1953.) 2*s*.; 0.24 dollars; 1 Sw. franc. [147

British Commonwealth Collections of Micro-Organisms. Directory and Catalogue of Collections of Micro-Organisms Maintained in Australia. Pp. 74. (Melbourne: Commonwealth Scientific and Industrial Research Organization, 1952.) [147

Veterinary Research. Vol. 1, No. 1, January 1953. Pp. ii+60. (Sapporo: Hokkaido University, 1953.) [147

Department of the Army: Corps of Engineers. Bulletin of the Beach Erosion Board. Special Issue No. 2: Shore Protection Planning and Design. (Preliminary, subject to revision.) Pp. 230+125. Beach Erosion Board: Office of the Chief of Engineers. Technical Memorandum No. 32: Accuracy of Hydrographic Surveying In and Near the Surf Zone. Pp. iv+17+11. Technical Memorandum No. 40: The Mechanics of Deep Water, Shallow Water, and Breaking Waves. Pp. ii+14. (Washington: Office, Chief of Engineers, 1953.) [147

Publications of the Astrophysical Observatory of the Czechoslovak Academy of Sciences, Ondrejov. Nr. 23: The Variation of the Frontal Zone During the Year in the Area of the Atlantic and Europe and in Relation to the Solar Activity. By Z. Gregor and L. Krivsky. The Long-Range Variability of Annual Precipitation in Prague-Klementinum in the Period 1805–1951 and in Relation to the Solar Activity. By L. Krivsky. Pp. 72. (Prague: Czechoslovak Academy of Sciences, 1953.) [207

World Health Organization. Technical Report Series No. 69: Expert Committee on Professional and Technical Education of Medical and Auxiliary Personnel. Second report. Pp. 26. (Geneva: World Health Organization; London: H.M. Stationery Office, 1953.) 1*s*. 6*d*.; 0·20 dollars; 0·80 Sw. francs. [207

World Health Organization. Monograph Series No. 16: Toxic Hazards of Certain Pesticides to Man, together with a Select Bibliography on the Toxicology of Pesticides in Man and Mammals. By J. M. Barnes. Pp. 129. (Geneva: World Health Organization; London: H.M. Stationery Office, 1953.) 7*s*. 6*d*.; 1.50 dollars; 480 French francs; 6 Sw. francs. [207

The South African Institute for Medical Research, Johannesburg. Annual Report for the Year 1952. Pp. 86. (Johannesburg: South African Institute for Medical Research, 1953.) [207

Family Planning Association of India. Third International Conference on Planned Parenthood. Report of the Proceedings 24–29 November, 1952, Bombay, India. Pp. xxxiv+247. (Bombay: Family Planning Association of India; London: International Planned Parenthood Federation, 1953.) 10*s*. 6*d*. [207

Unesco Science Co-operation Office for Latin America. Report of Activities during 1952. Pp. 17. (Montevideo: Unesco's Science Co-operation Office for Latin America, 1953.) [217